EFFECT OF DIFFERENT NUTRITIONAL STRATEGIES ON CARCASS TRAITS, MEAT QUALITY AND FATTY ACID COMPOSITION OF URUGUAYAN STEERS

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Abstract— Nutritional influences on carcass characteristics, meat quality traits and fatty acid composition of intramuscular fat were investigated on steers focusing on their significance in meat palatability and human health. One hundred and twenty Uruguayan Hereford steers were assigned to different treatments considering stocking and finishing periods. The diet was a combination of pastures (P) and concentrate (C) in each period. The treatments were: T1) C-C (n=30); T2) P-C (n=30); T3) C-P (n=30); T4) P-P (n=30), for first winter and finishing respectively. It was observed that steers on T1 had heavier carcasses (HCW), more ultrasound backfat thickness (BFTu) and marbling (MARB) than cattle from other treatments. Fat color was affected by treatments being more yellow carcasses from T4 (P<0.05). Beef from T3 and T4 were tender than beef from T1 and T2, with 2 days of ageing. Related to fatty acid composition, linolenic acid (18:3 n-3) content was higher (P<0.05) in P fed steers than C fed ones at fattening. However, it was not found any difference (P>0.05) in linoleic (18:3 n-6) content among treatments, as it was expected by diet effect. The polyunsaturated:saturated fatty acids (PUFA:SFA) ratios for T3 and T4 were higher (P<0.05) than those for T1 (0.17 and 0.18 vs 0.14, respectively). The omega 6: omega 3 (n6:n3) ratios were 4.1, 3.5, 1.8 and 1.4 for T1, T2, T3 and T4, respectively, being different (P<0.05) among treatments. It could be concluded that diet during finishing period had more effect on carcass and meat quality traits and FA profile. According with previous studies the use of C in this period improves carcass and meat quality of Uruguayan steers, but some concerns arise for tenderness and nutritional value of meat since n6:n3 ratios are in the no recommended levels for human health.

***Index Terms*— beef, pasture, concentrate, carcass traits, meat quality, fatty acid composition.**

I. INTRODUCTION

The quality of the meat depends on the social demographic of the consumer. Nowadays taste and nutritional value are two important quality attributes of meat for most of these consumers. The tendency is to produce lean animals with a minimum of fat thickness, but it is accepted that the amount and type of fat contribute to some organoleptic properties of meat as tenderness and flavor (Wood *et al*., 1997). Dietary recommendations for humans promoting the consumption of less saturated fat have led to an increased interest in meats containing more unsaturated fatty acids. Beef cattle growing programs can have deep effects on body composition and nutrient metabolism. These nutritional programs may alter the fatty acid composition of ruminant fat tissue. Recent researchs have focused on the nutritional importance of the n6:n3 fatty acid ratio in the human diet and on the content of conjugated linoleic acid (CLA) isomers because of their anticarcinogenic properties (Ip *et al*., 1994). The objectives of this study were to evaluate the effect of a combination of feeding regimes during the first winter of the animal (post weaning) and the finishing stage on carcass traits, meat quality and fatty acid composition.

II. MATERIALS AND METHODS

One hundred twenty Hereford steers from the same cowherd were treated under same conditions until weaning. After weaning they were sent to INIA La Estanzuela and were allotted randomly to each winter feeding programs (1st June to 30th August, 2008), pasture (P, n=60) or concentrate (C, n=60), with an average weight of 178 kg. Cattle grazed on oat and rye grass pasture (dry matter-DM: 3500 kg/ha). The DM allowance was 5% of the LW. The C diet consisted of 80% concentrate and 20% fiber. The average daily gain for this period was 1.3 and 0.8 kg/an/d, for C and P respectively. During the following Spring and Summer, the steers were handled together on pastures (alfalfa and oat) and were splitted for the finishing period, going to P or C (March 15th to September 15th, 2009) when a liveweight (LW) of 350 kg was reached. The treatments were: 1) C-C (n=30); 2) P-C (n=30); 3) C-P (n=30); 4) P-P (n=30), for first winter and finishing respectively. The steers were slaughtered in a commercial packing plant at 500 kg of final LW. Carcasses data was recorded (HCW) and were cut between the 10-11th ribs at 36 h postmortem, measuring fat color by AUSMeat system on the whole carcass using a 1 to 8 points scale. Steaks for Warner Braztler shear force (WBSF), meat color and fatty acid analysis were individually vacuum packaged and frozen for subsequent analysis. 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=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).

III. RESULTS AND DISCUSSION

The effects of feeding treatments on carcass traits and meat quality attributes are shown in Table 1. Although, it was not observed differences (P>0.05) in HCW, carcasses from T1 had heavier weights than those from the other treatments (260.1 vs 254.0, 247.8 and 252.3 kg. for T2, T3 and T4, respectively). The degree of finishing measured by BFTu was higher (P<0.05) in the animals finished with C (T1 and T2) than grass-fed steers during the fattening period (T3 and T4). Similar differences (P<0.05) were observed in marbling score where cattle eating C in the final period reached levels of Traces, meanwhile grazing animals showed Practically Devoid score. As it was expected, fat color was affected (P<0.05) by feeding regimes, having more desirable color (2.0 and 2.3 for T1 and T2, respectively) carcasses from grain fed steers during last days of fattening. Numerous studies have consistently shown that feedlot-finished cattle have whiter fat color scores than grass-fed animals (Realini *et al*., 2003). *Longissimus* muscle of animals in T1 and T2 had better (P<0.05) L* values than those in T3; however no differences were found among treatments T1, T2 and T4. Similar result was observed in Chroma ($\sqrt{a^2+b^2}$) muscle values, where meat from grain fed steers (T1 and T2) had higher values with 2 days of ageing, getting better appearance of color than meat from grass-fed cattle. Related to tenderness, T1 and T2 beef showed higher (P<0.05) values of WBSF (tougher meat) than T3 and T4 beef, at two days of ageing. This information is according with previous research in Uruguayan Hereford cattle, where concentrate fed steers presented the highest values of WBSF (Realini *et al*., 2003; del Campo *et al*., 2009). Our results differ from international studies reporting tender meat from feedlot than grass-fed steers.

The fatty acid composition of *longissimus* intramuscular fat (IMF) for all treatments is presented in Table 2. The IMF content was higher (P<0.05) in beef coming from T2 (4.5%) than beef from T1 (3.6%), T3 (3.0%) and T4 (2.8%). These values are higher than the mean IMF contents reported by Realini *et al*., (2003), but lower than ones reported by Brito et *al*., (2009). The main fatty acids in IMF for all treatments were oleic (18:1), palmitic (16:0) and stearic (18:0) which accounted for 84.5 % and 87.3 % of the total FA, for grass-fed and grain fed steers during fattening period, respectively. The percentages of oleic (18:1) were higher (P<0.05) in IMF of T1 and T2 cattle than those in pastures for finishing (T3 and T4). It was not found any differences (P>0.05) for linoleic (18:2 n-6) content among treatments, as it was expected by C effect. The linolenic (18:3 n-3) content was according to the offered finishing diet, where T3 and T4 beef showed more concentration of this FA than T1 and T2 beef (P<0.05). Realini *et al*., (2003) and Brito *et al*., (2009) reported that Uruguayan grass-fed animals had higher concentrations of linolenic acid than feedlot steers. In this study, it was found a clear difference (P<0.05) in long chain PUFA (arachidonic, EPA and DPA) between finishing diet treatments. PUFA content was higher in T3 and T4 (8.1% and 8.0%, respectively) than T1 and T2 (6.3% and 6.4%, respectively). Realini *et al*., (2003) have shown greater concentrations of stearic, linolenic, EPA, DPA and arachidonic acids in Uruguayan grass-fed than concentrate-fed animals. Total CLA varied (P<0.05) among treatments and was concordant with previous research showing that grass in the diet of beef cattle increased CLA concentration in IMF.

The meat from animals on T3 had higher (P<0.05) proportion of SFA than meat from steers on T1 and T2, although T1 and T2 beef had a higher (P<0.05) concentration of monounsaturated fatty acids (MUFA) than T3 and T4 beef. The UK Department of Health (1994) recommends that the PUFA:SFA ratio should be around 0.45. In this study the ratio was lower than this value (from 0.14 in T1 to 0.18 in T3), having grass-fed steers at finishing a higher ratio. Mandell *et al.* (1997) also reported a higher ratio for muscle from grass-finished steers than from concentrate-finished animals. An increase in human consumption of n-3 FA is also recommended (Department of Health, 1994) being n6:n3 ratio below 4. A more healthy n6:n3 ratio was found in T4 and T3 (1.4 and 1.8, respectively). Steers that were fed with C in both periods reached the highest (P<0.05) n6:n3 ratio (T1=4.1). These results are concordant with French *et al*., (2000) who reported ratios of 2.33 and 4.15 for grass-fed and concentrate-fed steers, respectively. This difference is normally assumed by the FA composition of the diet, where linolenic acid (18:3 n-3) is the major fatty acid in grass lipids while linoleic acid (18:2 n-6) is in grains. However, in this study it was not found any difference (P>0.05) among treatments in linoleic, being the content of long chain n3 PUFA the one that explained the observed n6:n3 ratio.

IV. CONCLUSION

Steers in T1 had heavier HCW, higher levels of BFTu and *longissimus* steaks with higher score of MARB. As it is shown in the literature, C at finishing period determines a better meat quality, mainly in meat and fat color. In this research, C fed steers showed a better values in L* and Chroma muscle parameters and whiter fat color by AUSMeat scale. In tenderness, P fed cattle was tender than C fed one. Beef from all treatments did not have differences (P>0.05) in content of 18:2 n-6 (linoleic acid) as it was expected. However, 18:3 n-3 (linolenic acid), long chain PUFA, especially n-3 ones and CLA contents were different among treatments, being higher in T3 and T4 beef. The n6:n3 ratio in IMF was higher from steers in T1 and T2 reaching no recommended levels for the UK Department of Health. Results from this study suggest that the feeding regime at finishing had more influence in most of the carcass and meat quality traits than the diet offered in the first winter of the animal. However, it was observed a tendency in T1 steers to have better values in those variables and worst in health attributes. The implications of this study will be according to the efficiency of the production system and its effect on carcass and meat quality attributes depending on market demands by those traits or human health recommendations.

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Table 1 - Mean carcass and meat quality traits of steers.

Traits	**T1**	**T2**	**T3**	**T4**	**P**
HCW (kg)	260.1	254.0	247.8	252.3	> 0.05
BFTu	8.7^{a}	8.2^{a}	6.2^{b}	6.4^{b}	< 0.01
Marbling	280.0^{a}	224.8^{b}	175.8^{b}	180^{b}	< 0.01
Fat cover color	2.0^{c}	2.3^{c}	3.9^{b}	4.3^{a}	< 0.01
WBSF 2 d	5.3^{a}	5.1^{a}	3.2^{b}	2.8^{b}	< 0.01
L* muscle 2 d	36.9^{a}	36.6^{a}	35.3^{b}	36.1^{ab}	< 0.05
Chroma muscle 2 d	20.9^{a}	20.1^{a}	19.4^{ab}	18.5^{b}	< 0.01

abc: Means within the same row with uncommon superscripts differ (P < 0.05).

Table 2 - Intramuscular fatty acid composition

Fatty Acid %	**T1**	**T2**	**T3**	**T4**	**P**
Intramuscular fat	3.6^{b}	4.5^{a}	3.0^{c}	2.8^{c}	<0.01
14:0 *myristic*	2.34	2.32	2.54	2.36	>0.05
16:0 *palmitic*	26.5^{ab}	26.0^{b}	27.4^{a}	26.8^{ab}	<0.01
18:0 *stearic*	16.1	15.8	17.1	16.3	>0.05
14:1 *myristoleic*	0.34^{b}	0.33^{b}	0.47^{a}	0.46^{a}	<0.01
16:1 *palmitoleic*	3.36^{b}	3.62^{ab}	3.45^{b}	3.91^{a}	<0.01
18:1 *oleic*	44.7^{a}	45.2^{a}	40.2^{b}	41.4^{b}	<0.01
18:2 *n-6 linoleic*	3.76	3.74	3.54	3.29	>0.05
18:3 *n-6 linolenic*	0.19	0.18	0.16	0.18	>0.05
18:3 *n-3 linoleic*	0.37^{b}	0.38^{b}	1.32^{a}	1.44^{a}	>0.05
20:3 *n-3*	0.27	0.25	0.28	0.30	>0.05
20:4 *n-6 arachidonic*	1.09^{ab}	0.98^{b}	1.36^{a}	1.09^{ab}	<0.01
20:5 *n-3 EPA**	0.22^{c}	0.28^{c}	0.52^{b}	0.67^{a}	<0.01
22:5 *n-3 DPA**	0.35^{b}	0.44^{b}	0.64^{a}	0.69^{a}	<0.01
CLA	0.28^{c}	0.27^{c}	0.47^{b}	0.59^{a}	<0.01
MUFA	48.4^{a}	49.1^{a}	44.1^{b}	45.8^{b}	<0.01
PUFA	6.3^{b}	6.4^{b}	8.1^{a}	8.0^{a}	<0.01
SFA	44.9^{b}	44.1^{b}	47.1^{a}	45.5^{ab}	<0.01
PUFA: SFA	0.14^{b}	0.15^{ab}	0.17^{a}	0.18^{a}	<0.01
n6:n3	4.1^{a}	3.5^{b}	1.8^{c}	1.4^{d}	<0.01

$^{a.b.c}$: Means within the same row 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.