BREED AND CASTRATION EFFECT ON FATTY ACID PROFILE OF NORTHERN SPANISH BEEF CATTLE

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Background

There is an increasing concern in developed countries about the consumption of dietary fat due to its association with cardiovascular and other lifestyle diseases, and for many years there has been emphasis on reducing the fat content from our diets. Meat producers have responded by reducing the fat content of beef by selective breeding, feeding practices and also by new butchery techniques (Hornick *et al*., 1998).
Both the amount and the composition of fat depots in beef may be influenced by factors such as breed or genotype, age or live weight, castration and gender, and feeding regime (Rule *et al*., 1995). In this sense, some breed effects on meat quality have been described out of two local breeds from Asturias in Northern Spain: "Asturiana de los Valles" and "Asturiana de la Montaña" (Oliván *et al*., 1999; Gil *et al*., 2001). On the other hand, steer production is gaining renewed interest because its effect on physico-chemical and sensory traits of meat (Steen, 1995; Osoro *et al*., 2001).

Objectives

The purpose of the present study was to examine the differences in fatty acid composition of muscle fat between bulls and steers in two different Spanish beef breeds ("Asturiana de los Valles" & "Asturiana de la Montaña") managed under grazing conditions.

Materials and methods

Animal management

Eight yearling bulls from "Asturiana de los Valles" (AV) (beef breed adapted to extensive production systems) and eight yearling bulls from "Asturiana de la Montaña" (AM) (small to medium-sized hardy animals, adapted to mountain systems) were reared under extensive conditions on ryegrass and clover pastures. Four animals from each breed were castrated between 10-12 months of age. All animals received a finishing concentrate diet during 60 days (84% barley meal, 10% soya meal, 3% fat, 3% minerals, vitamins and oligoelements) and barley straw *ad libitum* at the housing facilities of the Institute (S.E.R.I.D.A.). Animals were slaughtered with an average weight of 504 kg for AV bulls and 534 kg for AV steers, and 461 kg for AM bulls and 481 kg for AV steers. Slaughtering was performed in a commercial abattoir according to a routine procedure, and after dressing the carcasses were chilled at 3ºC for 24h.

Measurements

Twenty four hours *post-slaughter* the left half carcass was quartered and the part of the rib joint comprised between the 6th and 9th ribs extracted and transported to the laboratory. The 6th rib was excised and *Longissimus thoracis* (LT) muscle was separated, aged at 4ºC for 7 days and then minced with an electrical chopper, vacuum packed and kept at –20ºC until determination of intramuscular fat content by near infrared spectroscopy (Oliván *et al*., 2002). The LT of the 8th rib was extracted, vacuum packed and frozen at –80ºC for subsequent fatty acid composition analysis by gas chromatography (GC).

Total fatty acid analysis

The fatty acids were extracted in 5M KOH in methanol/water (50:50) at 60ºC for 1 hour and esterified at 40ºC during 10 min with 2M trimethylsilyl-diazomethane in *n*-hexane according to Elmore *et al*. (1999) with some modifications. Separation of fatty acid methyl esters was performed on a Varian CX3400 GC with a flame ionisation detector (FID) and a split/splitless injection port (50:1). GC analysis was performed using a B-PX 70 for FAME column (120m x 0.25mm i.d., 0.2µm film thickness) with programmed oven temperature. Injector and detector ports were set at 270°C and 300°C respectively. The carrier gas was hydrogen and the flow rate 1.6ml/min. measured at the initial temperature. Esterified fatty acids were

identified according to similar peak retention times using standards and quantified according to internal standard method ($C_{23:0}$ methyl ester) with its addition prior to saponification.

Statistical analysis
The statistical analysis was conducted using the SPSS11.5 program (2002). The effect of breed, castration and their interaction were studied by ANOVA analysis. Significance level of $p \leq 0.1$ was also considered.

Results and discussion
Table 1 shows the effect of breed, separately in bull and steers, and the effect of castration within both breeds on intramuscular fat and total fatty acid contents of *Longissumus thoracis*.

Breed effect on intramuscular fat percentage was seen in steers, but not in bulls, where AM steers showed more (4.74%) IM fat than AV steers (2.59%). Castration effect was significant only for AM breed where steers had (4.74%) a higher IM fat level than bulls (2.80%).

Breed effect on total FA composition was more pronounced in steers where significant ($p \leq 0.1$) differences were observed in 37% of the individual FAs, while in bulls only 18% of the individual FAs where significantly affected. In castrated animals, AV showed significantly higher quantities of *n-3* FAs than AM animals, and $C_{22:1}c13$ and $C_{18:2}$ *n-6* were also significantly higher in AV castrated animals. However, these differences were not observed in entire animals.
Studying FA groups, in general, breed effect was not significant, except for PUFA group because AV steers showed more PUFAs than AM steers. It should also be emphasised the significant difference in *n-6/n-3* and P/S ratio between steers of both breeds; AV steers showed lower *n-6/n-3* ratio (4.07) than AM steers (5.50). Higher P/S ratio was found in AV (0.49) than in AM (0.22) steers. Therefore, AV castrated animals meat would be the best adapted to the nutritional guidelines recommendations (P/S ratio between 0.45 and 0.70 and *n-6/n-3* ratio about 4.0) (Williams, 2000), and could happened due to a lower IM fat level of AV steers in comparison to AM steers (related also with the overall fatness; Osoro *et al*. 2001) probably reflecting the greater contribution of polar lipids located in membranes (phospholipids) and characterised with a high PUFA content in comparison to neutral lipids, storage lipid fraction (triacylglycerides) that are mainly composed of SFAs and MUFAs (Eichhorn *et al*., 1985; Choi *et al*., 2000; Lorenz *et al*., 2003).

Castration effect on total FA composition was low in AV breed, it significantly affected only to 22% of individual FAs where all of them were unsaturated FAs and appeared in higher quantities in steers than in bulls. This could be because of hormonal differences on enzyme activities (elongation & desaturation) (Malau-Aduli *et al*., 1998). However, castration effect was more remarkably for AM breed where significant differences were given for 70% of the individual FAs studied. AM steers showed in general higher quantities in comparison to AM bulls, particularly for saturated, branched and monounsaturated FAs, resulting significantly different also SFA and MUFA groups. But, it has to be pointed out that some FAs ($C_{18:2}$ *n-6*, $C_{20:2}$ *n-6* and $C_{18:3}$ *n-3*) appeared in higher quantities in bulls than in steers. These differences could be explained also with the lower fat quantity of bulls in comparison to steers and the greater contribution of phospholipids (PUFA) in comparison to triacylglycerides (MUFA & SFA) in this animals. In AM steers, they have higher IM fat proportions, individual FA variations may be more related to this fat content instead of to hormonal differences and enzyme activities caused by castration as might have happened in AV steers.
Studying FA ratios, there was not castration effect in *n-6/n-3* ratio for any breed. However, castration effect was observed in P/S ratio for AM breed, where bulls showed (0.48) a higher P/S ratio than steers (0.22).

Conclusions
Data from this preliminary study indicated that breed effect on intramuscular fat quality was more pronounced in steers than in bulls, what meant that breed effect was significant only when comparing animals with high IM fat level. Castration effect was more remarkable in AM breed than in AV breed. In general, AV steers produced the most nutritionally recommendable meat because of the good *n-6/n-3* and P/S ratios presented, and AM bulls produced a healthy meat from the P/S point of view.

References

Choi, N.J., Enser, M., Wood, J.D., Scollan, N.D. 2000. Effect of breed on the deposition in beef muscle and adipose tissue of dietary n-3 polyunsaturated fatty acids. Anim. Sci. 71: 509-519.

Eichhorn, J.M., Bailey, C.M., Blomquist, G.J. 1985. Fatty acid composition of muscle and adipose tissue from crossbred bulls and steers. J. Anim. Sci. 61(4): 892-904.

Elmore, J.S., Mottram, D.S., Enser, M. & Wood, J.D. 1999. Effect of the polyunsaturated fatty acid composition of beef muscle on the profile of aroma volatiles. J. Agric. Food Chem. 47: 1619-1625.

Gil, M., Serra X., Gispert, M., Oliver, M.A., Sañudo, C., Panea, B., Olleta, J.L., Campo, M.M., Oliván, M., Osoro, K., García-Cachán, M.D., Cruz-Sagredo, R., Izquierdo, M., Espejo, M., Martín, M., Piedrafita, J. 2001. The effect of breed-production systems on the myosin heavy chain I, the biochemical characteristics and the colour variables of *Longissimus* thoracis from seven Spanish beef cattle breeds. Meat Sci. 58: 181-188.

Hornick, J.L., Van Eenaeme C., Clinquart, A., Diez, M., Istasse, L. 1998. Different periods of feed restriction before compensatory growth in Belgian Blue bulls. I. Animal performance, nitrogen balance, meat characteristics, and fat composition. J. Anim. Sci. 76: 249-259.

Lorenz, S., Buettner, A., Ender, K., Nuernberg, G., Papstein, H.J., Schieberle, P., Nuernberg, K. 2003. Influence of keeping systems on the fatty acid composition in the *Longissimus* muscle of bulls and odorants formed after pressure-cooking. Eur. Food Res. Tech. 214: 112-118.

Malau-Aduli, A.E.O., Siebert, B.D., Bottema, C.D.K., Pitchford, W.S. 1998. Breed comparison of the fatty acid composition of muscle phospholipids in Jersey and Limousin cattle. J. Anim. Sci. 76: 766-773.

Oliván, M., de la Roza, B., Mocha, M. & Martínez, M.J. 2002. Prediction of physico-chemical and texture characteristics of beef by near infrared transmittance spectroscopy. Near Infrared Spectroscopy: Proceedings of the 10th International Conference, 197-202.

Oliván, M., Osoro, K., García, M.J., Noval, G., Martínez, A., Villa, A., De Diego, V.J., García-Atance, P. 1999. Características de la carne de terneros añojos de las razas Asturiana de los Valles y Asturiana de la Montaña. ITEA Vol. Extra 20: 98-100.

Osoro, K., Martínez, A., García, P., Oliván, M., Castro, P. 2001. Efecto de la raza, la castración y el acabado en los crecimientos, características de la canal y calidad sensorial de la carne de añojos cebados en pastoreo. ITEA Vol. Extra 22: 535-537.

Rule, D.C., Smith, S.B., Romans, J.R. 1995. Fatty acid composition of muscle and adipose tissue of meat animals. In: Biology of fat in meat animals (Ed., Smith, SB; Smith, DR), Current Advances series of the American Society of Animal Science, Champaign, Ill. p. 144-165.

SPSS 11.5. 2002. Guía Breve. SPSS Inc. Ireland.

Steen, R.W.J. 1995. The effect of plane of nutrition and slaughter weight on growth and food efficiency in bulls, steers and heifers of three breed crosses. Livest. Prod. Sci. 42: 1-11.

Williams, C. M. 2000. Dietary fatty acids and human health. Annales Zootechnie, 49: 165-180.

Acknowledgements

N.A. acknowledges a predoctoral fellowship awarded by the Spanish Ministry of Science and Technology (INIA) and thanks Dr. Celaya from S.E.R.I.D.A. for his advice and support on statistical analysis.

Table 1. Mean values of intramuscular fat (% IM fat) and total fatty acid (mg/100g meat) contents of *Longissimus thoracis* muscle. Signification level of differences observed depending on breed and castration.

	AV		AM		Breed		Castration	
	Bull	**Steer**	**Bull**	**Steer**	**Bull**	**Steer**	**AV**	**AM**
% IM fat	1.80	2.59	2.80	4.74	NS	*	NS	*
Fatty acid								
C14:0	19.80	41.08	29.71	92.10	NS	NS	NS	NS
C15:0	3.96	7.56	4.27	12.75	NS	NS	NS	*
C16:0	292.32	492.25	365.46	793.15	NS	NS	NS	*
C17:0	11.73	19.17	12.57	31.28	NS	+	NS	**
C18:0	209.23	278.02	232.63	362.42	NS	NS	NS	+
i-C15:0	0.75	1.70	0.85	1.79	NS	NS	NS	+
ai-C15:0	1.72	3.07	1.77	3.04	NS	NS	NS	+
i-C16:0	1.79	2.89	1.73	3.28	NS	NS	NS	+
i-C17:0	4.01	4.07	1.95	3.27	*	NS	NS	+
							NS	
C14:1*c*9	6.38	11.80	5.49	19.85	NS	NS	NS	+
C16:1*c*9	23.62	59.31	38.85	122.79	*	NS	NS	+
C17:1*c*10	6.93	15.88	8.74	28.37	NS	+	NS	**
C18:1*t*11	38.40	66.26	42.42	89.26	NS	NS	NS	*
C18:1*c*9	254.53	600.60	406.90	1015.89	+	NS	NS	*
C18:1*c*11	21.83	35.93	28.82	57.13	+	NS	+	*
C22:1*c*13	1.65	3.12	1.65	1.57	NS	***	*	NS
C18:2*n-6*	229.26	186.21	187.40	149.33	NS	*	NS	*
C18:3*n-6*	1.34	2.30	1.18	1.89	NS	NS	*	NS
C20:2*n-6*	1.90	1.79	1.87	1.53	NS	+	NS	*
C20:3*n-6*	10.94	14.11	9.43	11.77	NS	NS	*	NS
C20:4*n-6*	54.55	56.82	45.79	45.75	NS	NS	NS	NS
C22:4*n-6*	3.13	4.14	3.64	5.23	NS	+	NS	*
C18:3*n-3*	24.36	20.74	17.23	11.25	NS	***	NS	**
C20:5*n-3*	15.65	16.46	9.08	8.50	*	**	NS	NS
C22:5*n-3*	16.92	24.74	15.40	17.57	NS	**	**	NS
C22:6*n-3*	1.35	3.48	1.49	2.26	NS	*	**	NS
*c*9,*t*11 CLA	2.86	11.18	3.48	6.84	NS	NS	NS	+
Σ SFA	537.05	838.09	644.66	1291.71	NS	NS	NS	+
Σ MUFA	353.33	792.90	532.87	1334.86	+	NS	NS	*
Σ PUFA	362.28	342.00	296.02	261.94	NS	**	NS	NS
n-6/n-3	5.37	4.07	5.76	5.50	NS	**	NS	NS
P/S	0.69	0.49	0.48	0.22	NS	+	NS	*

+: $p \leq 0.1$; *: $p \leq 0.05$; **: $p \leq 0.01$; ***: $p \leq 0.001$; NS: $p > 0.1$. AV: Asturiana de los Valles; AM: Asturiana de la Montaña. *c*9,*t*11 CLA: *c*9,*t*11 C18:2; ∑SFA = sum of all saturated fatty acids; ∑MUFA = sum of all monounsaturated fatty acids; ∑PUFA = sum of all polyunsaturated fatty acids; *n-6/n-3* = (C18:2*n-6* + C18:3*n-6* + C20:2*n-6* + C20:3*n-6* + C20:4*n-6* + C22:4*n-6*) / (C18:3*n-3* + C20:5*n-3* + C22:5*n-3* + C22:6*n-3*); P/S = ∑PUFA / ∑SFA.