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MEAT QUALITY FROM PIRENAICA BREED RAISED UNDER DIFFERENT FEEDING SYSTEMS IN MOUNTAIN AREAS IN SPAIN

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I. INTRODUCTION

Mountainous regions, such as the Pyrenees, are characterized by traditional livestock farming systems, where animals graze on natural pastures located at different altitudes throughout the year [1]. These agroecosystems, rooted in extensive grazing, are a fundamental part of local culture and economy. Although farming systems in these regions often coincide in allowing cows and their calves to graze until weaning (around 5 to 6 months of age), they diverge thereafter in feeding strategies, incorporating concentrates, silage, or fresh pastures as the primary dietary sources [2]. These production systems typically vary in breed, feeding regimen, sex, and age at slaughter, which in turn affect the physicochemical and nutritional characteristics of the resulting meat cuts. In recent years, consumer preferences have shifted toward natural, nutritious, and health-promoting foods, with growing attention to sensory quality, environmental sustainability, and animal welfare. Within this context, meat from traditional mountain systems represents an attractive product, not only due to its origin but also for its nutritional value. The aim of this research was to evaluate nutritional composition of meat from young bulls reared in the Aragonese Pyrenees under different feeding systems, which are typical practices of mountainous areas.

II. MATERIALS AND METHODS

The Ethics Committee for Animals Experiments at the University of Zaragoza considered that this project was exempted from the scope of the Directive 2010/63/ EU and Spanish Policy for Animal Protection RD53/2013 on the protection of animals used for experimental and other scientific purposes. Twenty-five entire young bulls of Pirenaica breed, raised under three different feeding systems were used. In the first feeding system (FS1), calves (n=9) were raised with access to pasture and weaned at 180 days, then fed a concentrate-based diet until slaughter. The FS2 (n=8) followed a similar approach but with earlier weaning (150 days) and an organic concentrate-based diet, along with free access to forage. In the FS3 (n=8), calves had no pasture access, were weaned at 180 days, and fed a concentrate-based diet. All groups received cereal straw *ad libitum* during fattening. Animals were slaughtered at an average age of 13.5 ± 1.3 months. After 48 h post-mortem, three commercial cuts were obtained per carcass from the left side: Loin (LO), Rump Cap (RC) and Flank (FL). The raw meat was analysed for dry matter (ISO 1442:1997), total fat (ISO 1443:1973), protein (ISO 937:1978) and total ashes (ISO 936:1998). Total lipids were extracted with chloroform:methanol [3] and methylation with KOH, and fatty acid methyl esters were analysed by gas chromatography (HP6890). Data were analysed with SPSS 29.0 with a GLM procedure and Tukey test (P<0.050) was used to assess differences in the mean values.

III. RESULTS AND DISCUSSION

Significant differences in meat quality were observed between cuts and feeding systems. However, no interactions were found (Table1). The moisture content was higher in the FL, and in meat from animals reared with continuous access to forage (FS2), both over 73.8 g of water per 100 g of meat (P<0.001). Higher protein was found in LO compared to FL (24.1 vs. 23.2 g/100 g, P<0.001) and in the meat from animals raised in the FS1 (24.3 g/100 g, P<0.001). The fat content was 50.3 % higher in meat from animals fed concentrate-based diet (FS3), as this type of feed maximizes the availability of net energy and glucose for fat synthesis, compared to grass feeding. Nevertheless, all commercial cuts and feeding systems could be considered low-fat, as they contained less than 3 g of fat per 100 g of meat [4]. Although low-fat, the effects on the fatty acids (FA) profile were still evident, particularly for cuts, as shown in Table 1, which presents the sum of the main FA found. The monounsaturated fatty acids (MUFA) ranged from 39.5 to 41.4 g/100g, with not significant differences, due the lack of variations in oleic acid contents, for both commercial cuts and FS. Influenced by the higher palmitic and stearic acids, the LO was 16.3% higher (P<0.001) in saturated fatty acids (SFA) than the other cuts. Additionally, due to their lower C18:2 n-6 content, polyunsaturated fatty acids (PUFA) level was 24.4 % lower in LO, resulting in a 34 % reduction in the PUFA/SFA ratio compared to the other cuts (0.35 *vs*. 0.53 g/100, P<0.001). Nevertheless, with the exception of the LO, the assessed cuts showed

a PUFA/SFA ratio above 0.4, which is the recommended level [5]. Grazing animals showed meat with 25 % higher levels of C18:3 *n*-3, due to its presence in the grass, leading to a 32 % increase in *n*-3 PUFA content and a more favorable *n*-6/*n*-3 PUFA ratio. This ratio was 22.6 % lower in meat from FS2, although it remained considerably above the recommended level of 4 [5, 6]. Moreover, all meat analysed exceeded the recommended limit, particularly the LO and FS1 (14.6 and 15.3, respectively; $P<0.01$). Despite the significant differences associated with the feeding systems, the fatty acid profile was mainly influenced by the commercial cuts, indicating in this study, that the variation observed is mainly attributed to anatomical location of the muscle rather than to the feed.

Table 1. Proximate composition (g/100 of edible portion [muscle + visible fat]) and fatty acids profile (g/100 g of total FA of edible portion [muscle + visible fat]) of beef from different commercial cuts of young bulls raised in different feeding systems.

	Cut			Feeding System			SEM	Cut	FS	Cut x FS
	LO	RC	FL	FS1	FS2	FS3				
n	*25*	*25*	*25*	*9*	*8*	*8*				
Moisture	72.4 a	72.9 a	73.8 b	72.8 Y	73.9 X	72.6 Y	0.141	<0.001	<0.001	0.208
Protein	24.1 a	23.6 ab	23.2 b	24.3 Z	22.9 Y	23.7 X	0.114	0.001	<0.001	0.955
Fat	2.27 ab	2.28 a	1.75 b	1.87 Y	1.75 Y	2.72 X	0.105	0.031	<0.001	0.324
Ash	1.20	1.21	1.20	1.12 Z	1.52 Y	0.99 X	0.033	0.952	<0.001	0.983
SFA	43.6 b	37.9 a	37.0 a	38.6 Y	40.3 X	39.8 XY	0.437	<0.001	0.038	0.655
MUFA	39.6	40.1	41.4	41.0	39.5	40.6	0.534	0.392	0.508	0.987
PUFA	15.0 b	19.8 a	19.8 a	18.4	18.1	18.0	0.640	0.002	0.946	0.827
n-3 PUFA	0.976 b	1.49 a	1.36 a	1.11 Y	1.53 X	1.21 Y	0.060	<0.001	0.006	0.864
n-6 PUFA	13.6 b	17.9 a	18.0 a	16.8	16.2	16.3	0.595	0.003	0.900	0.832
PUFA/SFA	0.348 b	0.525 a	0.542 a	0.488	0.460	0.462	0.020	<0.001	0.779	0.730
n-6/*n*-3 PUFA	14.6 b	12.5 a	13.5 ab	15.3 Z	11.3 Y	13.8 X	0.312	0.001	<0.001	0.368

SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; *n*-6: omega 6; *n*-3: omega 3. Different letters indicate statistical differences within cuts (a-c) or within feeding systems (X-Z) ($P<0.05$). SEM: Standard Error of Mean.

IV. CONCLUSION

The most pronounced variations were observed among commercial cuts All meat analysed could be considered high-protein and low-fat. Although the loin showed the greatest variation in the FA profile, the fat content remained below 3 % in all cuts. The studied feeding systems had little or no influence on the FA profile of the meat, except for SFA, *n*-3 PUFA and *n*-6/*n*-3 PUFA ratio, whoose differences were mainly due to grazing, which is characteristic in mountainous pastures such as those in the Pyrenees.

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