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PERFORMANCE OF CROSSBREED FATTENED CALVES IN COMMERCIAL FARMS IN SPAIN

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ABSTRACT

In the present study, parameters related to animal performance and carcass quality were evaluated in order to technically characterize crossbreed calves under commercial farm conditions. Sixty-six male calves of Holstein Frisian crossed with Rubia Gallega (n=43; 65.15%), Limousine (n= 16; 24.24%) and Belgian Blue-White (n=7; 10.61%) were used, in a ratio representative for the beef industry of the area. Nutrition and husbandry practices were identical for all the animals. All the calves were slaughtered at the age of 8 months. Results indicated that the Belgian Blue-White crosses were the heaviest, more compact and with the best body conformation, and also a better carcass performance. On the contrary Limousine crosses showed the leanest carcass and the lowest performance. The carcasses of Rubia Gallega crosses showed intermediate characteristics. No statistically significant differences were found in the fatness content between the three genotypes.

Keywords: beef crosses, slaughtered age; commercial farms, morphometric characters, carcass traits.

Abbreviations: Rubia Gallega (GB); Holstein Frisian (HF); Limousine (LIM); Belgian Blue-White (BBW); Total Carcass Length (TCL); Chest External Width (CEW); Chest Internal Width (CIW); Hindlimb Length (HL), Hindlimb Width (HW); Maximum Hindlimb Perimeter (MHP); Carcass Compactness Index (CC).

INTRODUCTION

In crossbreeding programs, breed combination should be dictated by the demands of the markets for particular traits at harvesting, which depends on the genetic value of the ascendants and the level of heterosis, the breeds´ adaptability to specific environments, the availability of the breeds in the area and the breeder's preference (Williams *et al*., 1991). Genotype is of high relevance for the conformation, which is an important economical criterion since it is closely related to the carcass efficiency (Mata, 1984; Martin *et al*., 1993; Sánchez Fernández, 1996; Sañudo and Campo 1998).

There is a close relationship between the animal shape (muscle scoring) and muscular development (muscling), so the amount of edible meat could be determinate independently of fatness (More O´Ferral and Keane, 1990; Albertí *et al*., 2005).

Beef production in Galicia (NW Spain), with 260000 calves per year, represents 25% of the market for Spanish consumers (MARM, 2011). In this area, beef production consists of industrial crosses corresponding to 65% of the regional production volume. The rest corresponds to autochthonous purebreds, mainly Rubia Gallega (GB) with a 26%. Thus, most common programs use Holstein Frisian (HF), Limousine (LIM), Belgian Blue-White (BBW) and GB. Galician beef cattle production systems are characterized by a production cycle of seven to nine months of age for the calves, with a finishing weight between 300 to 400 kg and a carcass yield of 60% (Bispo, 2010).

The unique quality of Galician beef prompted the European Union to accept, in 1996, the protected geographical indication (PGI) of Galician Veal “Ternera Gallega”, which comprises pure GB and its crosses (EC 2400/96). This denomination label carried the consumers’ recognition of the reputed quality for the “Ternera Gallega” meat. Nowadays the PGI “Ternera Gallega” is the mayor reference in Spain regarding the commercialization of high quality meat, and 48 % is marketed in Galicia, 50 % in other areas of Spain and 2% exported. Under PGI “Ternera Gallega” classification, the slaughter time in 98% of calves is earlier than ten months of age (Ternera Gallega Annual Summary, 2008).

Numerous research studies assessing the productivity of crossbreeding calves (GB x HF) including their carcass and meat qualities are available (Dios *et al.*, 1997; Sánchez Fernández *et al*., 1997). Still, available scientific documentation about those crossbreeding refers always to calves reared under experimental conditions and slaughtered over one year old.

Comparative results of production and meat quality of beef crosses are needed. Thus, the objective of the current study was to assess crossbreeding effect in carcass and meat quality of calves for the breeds slaughtered under commercial farm conditions.

MATERIALS AND METHODS

Animals and management: For this survey, data of 66 carcasses were analyzed. Steers carcasses originated from 3 groups of possible crossbreeding programs using: GB x HF (n=43), LIM x HF (n=16) and BBW x HF (n=7), in a representative proportion of the market.

Male calves used in this trial were purchased at the age of 40 days, from different representative commercial farms. Thereafter they were reared under the typical production system, in the same barn/facilities and were fed with the same feed ration.

Early in the post-weaning period, calves were temporarily fed with milk replacer, at a dose of 100 g of milk powder per liter of water and a quantity of two liters of milk in each shot, twice a day. The quantity of milk fed was reduced gradually in combination with increasing amounts of a starter concentrate so that at 5 weeks of the experiment, the starter concentrate was given alone, with straw and water available *ad libitum*. This diet was supplemented with vitamin A (25000 UI/kg), vitamin D_3 (5000 UI/kg), vitamin E (30 mg/kg), and butyl-hydroxytoluene.

During the finishing period, from four months until slaughter (lesser than ten months or at 360 kg live weight), they were fed finishing concentrate and hay *ad libitum.*

Detailed of the ingredients and “chemical” composition during the different feeding periods are presented in Table 1 and 2.

Carcass quality and genotype parameters: After dressing, carcasses were chilled at 7–10 °C for 24 h until sampling following the standard procedures at the slaughterhouse.

A trained and experienced evaluator assessed carcass conformation by automatic visual-image carcass assessment equipment. Classification of carcass quality was obtained applying the official European standards (EEC 103/2006): SEUROP for conformation profiles and a 5-point scale for fat cover degree.

Carcass quality assessment was always performed on the left side of carcasses. Quality gradients were established based on double images from the hemi-carcasses, one in lateral (external) view and the other in dorsal view. The lateral view aimed the carcass profile identification (concave, convex or straight) from each of the main anatomic regions with morphologic influence (round, back and shoulder). The dorsal view allowed evaluating the muscular development based on anatomic prominent points. The fat cover degree was assessed for the whole carcass.

Carcass conformation was assessed based on the development of carcass profiles, especially for the round, back and shoulder. Adopted conformation classes/scores where: Superior (S=1), Excellent (E=2), Very Good (U=3), Good (R=4), Fair (O=5), and Poor (P=6) (EEC 103/2006). The degree of cover fatness was determined by the amount of fat on the exterior of the carcass and, internally, in the thoracic cavity; scoring of the amount and distribution of the cover fat, with special emphasis in the thoracic cavity, followed the official european standards (EEC 103/2006): Low fat (1), Slight (2), Average (3), High (4) and Very High (5).

Additionally, the degree of kidney fat covering was determined by the amount of fat adherent to the kidney capsule. Four scores were established: (1= Covered; 2= Small Window; 3= Big Window; 4= Uncovered). It was also evaluated the marbling of intercostal (inner side) and abdominal muscles (under the epimisium of the inner muscle layer of the abdominal wall) using a 5-point scale (1= No fat; 2= Visible muscle; 3= Slight marbling; 4= Moderate marbling; 5= Important fat deposits).

The method of De Boer (1974) was used to assess objective carcass measurements and the carcass index. Briefly, six measures were taken over the left hemi-carcass 24 hour *post-mortem*: Total Carcass Length (TCL), Chest External Width (CEW), Chest Internal Width (CIW), Hindlimb Length (HL), Hindlimb Width (HW) and Maximum Hindlimb Perimeter (MHP). To set a correlation between carcasses, two indices were used: the Carcass Compactness Index (CC) (CC=carcass weight/carcass length) and the Transverse Hindlimb Longitudinal Index (Hindlimb Length/Hindlimb Perimeter).

Statistical analysis: Data were subjected to statistical analysis using the General Linear Model (GLM) procedure of the SAS statistical software package (SAS, 2000). Duncan’s Multiple Range Test was used with factors that significantly affected the crossbreeds´ performance.

RESULTS AND DISCUSSION

Carcass conformation: The results for the carcass quality traits in the three crossbreeds steers used in this survey are presented in Table 3, either for subjective (carcass profile and fat cover description) and objective (measure and index) parameters. GB x HF crosses got a remarkable better conformation, acceptable fat cover and the bigger hind limb size compared to the other crosses. Carcasses of LIM x HF crosses were the less compact and with more carcass fat than the former. BBW x HF crosses presented the most uniform carcass, since all the carcasses presented the same score for conformation; they were also the heaviest and the most compact.

The analysis of variance performed for genotypes showed the existence of highly significant differences between the three genotypes. The best conformation was found in the carcasses of BBW crosses (all of them classified as U), while for the carcasses of GB crosses a less homogeneous trend was found, with 53.49% reaching U classification while 46.51% got R classification. LIM crosses showed the lowest scores for conformation (18.45% and 81.25% for grades U and R respectively).

In the present study, the values obtained by the GB crossed steers for the carcass conformation were lower than those found by Campo *et al.* (2000), which reported 68.75% of carcasses classified as U; however, the study was developed in yearling calves. Similar results were found in two other Spanish breeds such as Bruna dels Pirineus (Serra *et al.*, 1999) or Pirenaica (Panea *et al.*, 1999), although these are reported superior to other native Spanish breeds such as Morucha or Avileña-Negra Ibérica (García and Cruz-Sagredo, 1999ab; Campo *et al.*, 2000), for the same age. Those differences should be regarded as very positive in terms of performance, particularly when accounting for the age differences between those studies and ours. At 8 months old, muscle plains are not fully developed. The advantage of GB crosses should be emphasized due to the proportion of U and R classifications, with the former classification prevailing, as expected for males. This pattern has been supported by other studies (Vallejo *et al*., 1991; Micol *et al*., 1993; Dios *et al*., 1997; Dios, 2000). Thus, beside the sex, the animals´ age should always be considered as a major influence factor.

Conformation and age together with the improvement of the subjective qualification has been significantly correlated in several published data. It is well documented that carcass conformation and the fat cover degree increase in parallel with the increase of weight at slaughter (García de Siles and Gálvez, 1976; Colomer-Rocher, 1980, Kempster *et al.*, 1982, More O´Ferral and Keane, 1990). Sueiro *et al.* (1995) and Monserrat *et al.* (1997) reported similar findings in GB animals. The number of animals included in category R decrease as age increases, thus increasing the percentage of carcasses in higher categories. Monserrat *et al.* (1997) tried to explain such differences in conformation by the decrease in the distance to the maturity age. Those findings seem to be corroborated by Varela *et al.* (1997), who compare seven and ten months old-GB calves, showing that muscle, bones and fat increase with the weight of the carcass. In contrast, connective tissue was higher in seven months old calves, which could be explained by lower muscle and subcutaneous fat percentages.

Fat cover degree: Carcass fat score is an important trait affecting profitability of farms and the entire beef chain. More than 90% of the carcasses in the present study were under scores 2 and 3. Similar results have been reported by different authors (Sueiro, 1994; Carballo *et al*., 2000; Dios, 2000). Comparable results were also obtained in yearly purebred calves of the breeds Pirenaica and Parda Alpina (Albertí *et al*., 1995). Our findings should be envisaged as a favourable characteristic since the current consumer tends to select lean meat (Banović *et al*., 2009) and adds competitiveness compared to other low fat meat. To obtain a fattening degree of 2-3 at an early slaughtered age, specific feed supplementation and fattening techniques are required. The difficulty is to increase fatty deposits in late growth stages in younger animals without a high energetic feed supplement (Owens *et al*., 1993).

The highest fat cover degree was showed in LIM crossed carcasses; yet it did not differ from the other two crosses in study. Breed differences in fat covering result from variation in the triglycerides/phospholipids ratios (Eichhorn *et al*., 1986), or from differences in the genes that regulate the fatty acids unsaturation and the accumulation of lipids in distinct anatomical locations (Rhee *et al*., 1982). Breed particularities have been described for Rubia Gallega with a small fat covering evenly distributed over the surface of the carcass, as ought to ensure the protection of the underlying muscle against changes associated to low temperatures and weight lost through dehydration (Dios, 2000). Nevertheless, some authors consider that differences between breeds are due more to the amount of fat they deposit (Nürnberg *et al*., 1998) than to fatty acid variations (Anderson *et al*., 1986).

Kidney fat cover: The presence of abundant pelvic and perirenal deposits is indicative of poor carcass quality, as it happens in breeds of dairy aptitude (Holstein Friesian and Jersey). In contrast, beef cattle such as Limousine, Charolais and Hereford tend to favor accumulation of subcutaneous fat instead of visceral fat (Bass *et al*., 1981). Consistently, in the present study, the most usual category for the kidney fat cover was the score 3 ("big window"). Previous reports in 6 to 9 months old GB calves also refer to high kidney fat cover levels but scored as 2 (small window) (Sueiro, 1994; Dios, 2000). Vallejo *et al.* (1991) obtained comparable results but in Asturiana breed animals aged between 14 and 21 months. In the study presented herein, percentages obtained for score 3 were 67.44%, 56.25% and 42.86% respectively for GB, LIM and BBW crosses. The lowest amount of fat was found in crosses with HF; in a small percentage of

BBW x HF cross and the highest amount in LIM x HF calves.

Marbling level: Results obtained for carcasses marbling levels in the present study matched with those previously described by Dios (1997) for GB x HF animals sacrificed at 7-9 months old, which were classified into the marbling score 2. Sueiro *et al.* (1995) also rated marbling class 2 as the most frequent classification for GB calves. Furthermore, this study reported that as long as the carcass weight increase, the number of carcasses included on marbling level 1 decrease while the muscular marbling carcasses get higher scores.

Objective carcasses assessment: The carcass measurements and the carcass index showed differences between the crossbred groups, with exception for the total carcass length and chest internal width. Overall, carcasses of BBW crosses were significantly thicker and more compact than those of GB and LIM crosses, in this order.

Results in our study allowed to objectively differentiate the carcasses at young ages in regard to the most valuable economic traits, such as the hid limb volume, where the most valuable pieces of meat are located. The GB crosses provided an average Transverse Hindlimb Longitudinal index of 3.23, considerably superior to the 2.94 index obtained by BBW cross breeding, despite the later had obtained the major carcass compactness, mainly due to the great carcasses weight.

According to Panea *et al.* (1999) the carcass compactness index for the Pirenaica breed achieved higher scores with the increase of the weight at slaughter. However, the hind limb length/width ratio was not related to weight at slaughter, thus impairing to find visual differences in the carcass. This agrees with Barriada (1995) work in Asturiana de los Valles. Nevertheless, though the former studies used older animals, this finding is still valid, since thicknesses and lengths also increase with increasing age. Our results fully agreed with the reported by Sánchez *et al*. (1999) on 18 to 24 months old "Ternera Gallega" males, whether intact or castrates. According to these authors, calves age affects all measures and index. There is a close relationship among age and body development, even when animals did not reach adult age once GB is a late-maturing breed.

Table 1. Ingredients of the concentrate supplied in the present study and percentage of the total ration

Initiation concentrate*	**Starter concentrate**	**Finishing concentrate**
Age (up to 45 days)	Age (up to four months)	Age (up to 10 months or 360 kg)
Corn	Corn (34.9 %)	Corn flour (38 %)
Barley beer	Soybean flour (18.3 %)	Corn gluten (17 %)
Soya flour	Corn distillery (10.8 %)	Soybean flour (10.5 %)
Soybean husk	Barley flour (9.6 %),	Wheat bran (10 %)
Residues from corn distillery	Wheat flour (7.3 %)	Wheat flour (8 %)
Serum (70/12)	Wheat bran (6.3 %)	Dried residues from wheat distillery (5.5 %)
Phosphate dicalcium (18%)	Soybean husk (4.4)	Barley flour (5 %)
Calcium carbonate	Sugar cane molasses (3 %)	Calcium soaps of palm oil (2 %)
Salt	Lucerne flour (2.7 %)	Sugar cane molasses (1 %)
Binder	Calcium carbonate (1.59 %)	Calcium carbonate (0.9 %)
Vitamin mineral corrector	Palm tree oil (0.7%)	Sodium bicarbonate (0.7 %)
Aroma	Sodium bicarbonate (0.52 %)	Palm oil (>90% hydrogenated) (0.5 %)
	Sodium chloride (0.34 %)	Sodium chloride (0.5 %)
	Monocalcium phosphate (0.25 %).	Calcium phosphate (0.07 %)

* Percentage was not available.

Table 2. Chemical composition (%) of different concentrates on the diet used in the study

	Initiation	**Starter**	**Finishing**
Dry matter (%)	87.93	87.62	87.12
Protein (%)	18.00	18	17.61
CF (%)	3.74	4.11	4.20
Ash (%)	5.87	6.04	7.78
Starch (%)	38.51	38.39	35.90
Sugar cane molasses (%)	5.80	4.74	4.81
EE	3.64	2.53	2.04
Calcium (%)	0.90	0.90	0.84
Phosphorous (%)	0.70	0.65	0.63

In the present study, the total length of the carcasses ranged from 111.94 to 113.0 cm, the longest carcases belonging to the BBW x HF and the shortest to GB x HF, though no differences existed for this trait among tested crossbred groups. Considering this parameter, Arthur *et al.* (1995) reported a total length of 95.2 cm for Charolais carcasses of calves' aged of 281 days old.

In contrast to the reported for Serrana Soriana calves (Asenjo *et al.*, 1999), in our animals the width measures were predominant over the length measurements. Also, although Morucha calves presented longer carcasses (133 *vs.* 112 cm) when slaughtered at an averaged live weight of 436 kg (higher than the 360 kg obtained in the present study), the values for the hind limb length were not too different from ours (78 *vs.* 74 cm) even if slightly higher for the hind limb thickness (33 *vs.* 23 cm).

Table 3. Differences among industrial Holstein Friesian crossbreds in the different parameters for carcass quality based on the slaughterhouse records and the objective measures taken from the carcass and analysis of variance for the genotypic effect. Data followed by a different letter in the same file are significantly different (P<0.05; Test Duncan)

Genotype (number of animals)	**GB x HF (43)**	**LIM x HF (16)**	**BBW x HF (7)**	**F**
Carcass weight (kg)	197.37 ± 14.57a	191.6 ±6.37a	218.0 ± 11.86b	***
Performance (%)	55.45 ± 1.87a	54.9 ± 1.38a	59.45 ± 1.43b	***
Subjective measures				
Conformation	3.53 ± 0.50a	3.81 ± 0.40a	3.00 ± 0b	***
Fat cover degree	2.51 ± 1.40	3.19 ± 1.79	2.57 ± 1.13	ns
Kidney fat cover	2.42 ± 0.88	2.19 ± 0.98	2.43 ± 1.13	ns
Marbling	1.81 ± 0.53	1.97 ± 0.42	1.75 ± 0.50	ns
Carcass measures				
TCL (cm)	111.94 ± 4.23	112.6 ± 3.96	113.0 ± 3.51	ns
CIW (cm)	37.26 ± 1.71	36.9 ± 1.50	37.9 ± 1.21	ns
HL (cm)	74.48 ± 2.24b	72.6 ± 2.47a	73.9 ± 2.14	*
HW (cm)	23.17 ± 1.37a	22.7 ± 1.19a	25.1 ± 0.90b	***
MHP (cm)	100.7 ± 3.29a	100.3 ± 2.08a	104.1 ± 2.91b	**
CEW (cm)	54.45 ± 2.22a	54.1 ± 2.10a	56.4 ± 1.74b	*
INDEX				
CC (kg/cm)	1.76 ± 0.11a	1.70 ± 0.11a	1.93 ± 0.09b	***
Transverse Hindlimb Longitudinal (cm)	3.23 ± 0.23a	3.20 ± 0.13a	2.94 ± 0.12b	***

Abbreviations are: TCL: Total Carcass Length, CIW: Chest Internal Width, HL: Hind limb Length, HW: Hind limb Width, MHP: Maximum Hind limb Perimeter, CEW: Chest External Width, CC: Carcass compactness, Transverse Hindlimb Longitudinal.

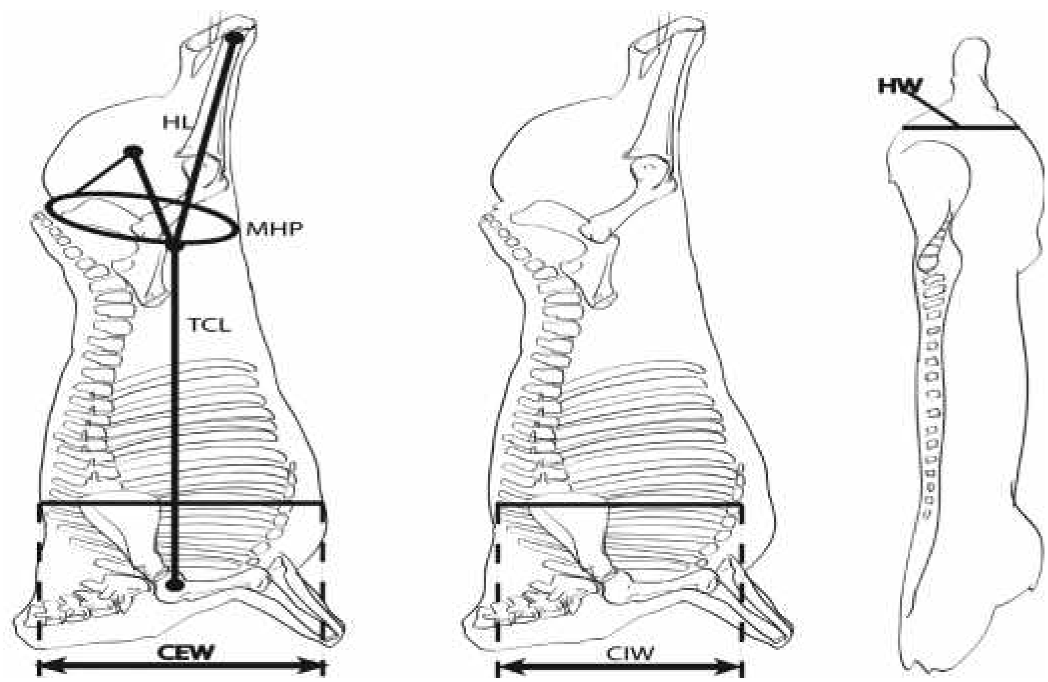

Figure 1. Length and width measures taken over the left carcass side 24 hours post-mortem. Abbreviations are: TCL: Total Carcass Length, CIW: Chest Internal Width, HL: Hind limb Length, HW: Hind limb Width, MHP: Maximum Hind limb Perimeter, CEW: Chest External Width, Transverse Hindlimb Longitudinal.

Conclusions: Accounting the standard slaughter age, the heaviest carcasses, the better shaped, more compact and higher performance were those obtained from the BBW x HF cross breeding. The lightest and lower performance carcasses were the LIM x HF cross breeding. The GB x HF carcasses occupied an intermediate position, but with higher hind limb volume. There were no statistically significant differences on fat cover degree between crossbred groups.

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