PRODUCTION AND CARCASS QUALITY OF TEN BEEF CATTLE BREEDS OF THE SOUTHWEST OF EUROPE

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ABSTRACT

A sample of about 70 young bulls of each of ten beef cattle breeds reared in their typical production systems has been studied regarding growth and carcass quality traits. Breeds included were Asturiana de los Valles (AV), Asturiana de la Montaña (AM), Avileña-Negra Ibérica (A-NI), Bruna dels Pirineus (BP), Morucha (Mo), Pirenaica (Pi) and Retinta (Re) from Spain, and Aubrac (Au), Gasconne (Ga) and Salers (Sal) from France.

There existed large differences between breeds and also within breeds. AV and Pi were the breeds with more muscle and less fat, whereas A-NI, Mo and Re were in the opposite side. BP and AM occupied an intermediate position. This allows to classify the Spanish breeds in three groups: AV and Pi would belong to the group of late maturity, A-NI, Mo and Re, would be early maturing breeds, whereas BP and AM, despite the small size of the last, will be of intermediate maturity. In the French populations, Au was the breed with the highest carcass weight and Ga exhibited the lowest. Sal occupied an intermediate position, showing the longer and thinner thigh.

In a wide range of carcass weight, the general relationships among carcass traits have been confirmed. Animals with the better conformation were also the leaner and longer carcasses tended to be lowly associated with a poorer conformation and fatter carcasses. Bone

content was clearly opposed to carcass conformation and muscle content and was associated with longer carcasses

INTRODUCTION

According to FAO (FAO 1998), the utilisation of appropriate farm animal genetic resources to achieve and maintain sustainable production systems which are capable of responding to human needs, is necessary to national and global food security. A first step in the management of these resources includes their identification, description and characterisation. The probability of survival of a population or breed, moreover, is strongly linked to its ability to meet current and future market demands, in our case quality meat.

Several experiences were carried out previously to characterize production, carcass and meat quality traits of the Spanish breeds (Vallejo 1971; Vallejo *et al*. 1991; Vallejo *et al*. 1992; Benito *et al*. 1987; Ruiz *et al*. 1987). Provided that the beef cattle breeds are submitted to selection programs and that management and feeding systems evolve rapidly, studies on production, carcass and meat quality characteristics are needed on a periodical basis. Recently, Albertí, Sañudo and coworkers (Albertí *et al*. 1995; Santolaria *et al*. 1997; Sañudo *et al*. 1998; Campo *et al*. 1999) have made a comprehensive study on carcass and meat quality traits of seven breeds, six of them involved in this study. Their project, including 18 animals per breed, aimed at the comparison of the breeds on standard feeding, rearing place, pre slaughter and post slaughter conditions with a slaughter weight similar for all breeds (450-470 kg). For the some local French breeds, this is the first study on carcass and meat quality.

Our project FAIR1 CT95 0702 has as a goal to describe both the between and within breed-production system variability of beef cattle breeds from France and Spain reared on their typical production systems and slaughtered at commercial weights. The between breed variability represents the joint effect of the genetic differences between breeds and of the feeding system. Within breeds, the observed variability has a genetic component, suggesting the possibilities for within breed genetic selection.

This project was developed on a large sample size (more than 70 animals per breed-production system). The experimental design was established to achieve statistically significant results on the relationships between the traits analyzed. In this paper, we present the variability relative to production and carcass quality variables. Results on meat quality are presented in a separate paper.

MATERIALS AND METHODS

Animals

Seven Spanish local beef breeds: Asturiana de los Valles (AV), Asturiana de la Montaña (AM), Avileña-Negra Ibérica (A-NI), Bruna dels Pirineus (BP), Morucha (Mo), Pirenaica (Pi) and Retinta (Re), and three French local beef breeds: Aubrac (Au), Gasconne (Ga) and Salers (Sal) were studied in two consecutive years. The geographical distribution of the breed – production systems are presented in figure 1.

Growth and slaughter conditions

All animals were reared under local production systems and slaughtered in their areas of origin in commercial EU licensed abattoirs. In Spain, fattening started at about 5 to 8 months of age and calves were fed *ad libitum* a diet based on concentrated meal and straw or hay. Average slaughter weight was breed specific, depending upon the degree of maturity and market preferences. The range for the average slaughter weight of Spanish breeds was 450-550 kg (table 1).

In France, young Au bulls started fattening at an average age of 19 months, and were fed maize silage and hay *ad libitum*, complemented with concentrates, during 4-6 months. In the Ga breed, fattening started when young bulls were about 7 months old, being fattened during 9 months with maize silage *ad libitum* complemented with concentrates. Animals of Sal breed started fattening at 9-10 months being fed grass and maize silage *ad libitum* complemented with concentrates during 10 months. To provide more details about the samples, figure 2 presents a scatter plot of weights and ages of young bulls.

Carcass evaluation

Standard carcass evaluation was carried out in all young bulls 45 min after slaughter following CEE 390/81, CEE 1208/81, CEE 2930/81 and CEE 1026/91 rules. Several people were trained before starting the study for standardising and increasing the precision of measurements. Variables assessed by were the following:

- Hot carcass weight measured without removing the fat, and maintaining the testicles and perirenal and pelvic fat. The tail must remain on the right half-carcass.
- Dressing percentage (DP) calculated according to the formula (hot carcass weight / slaughter weight) x 100.
- Conformation score (CONF) was graded according to the EUROP classification with a scale ranging from 15 (very good conformation) to 1 (very bad conformation. The

corresponding EUROP grading is as follows: E+, E, E-, U+, U, U-, R+, R, R-, O+, O, O-, P+, P, P-).

- Fatness score (FAT) was measured on a 1-15 scale (1, very low fat; 15, very high fat). With respect to a 1-5 classification, the equivalence of the scale used is 1-, 1, 1+, 2-, 2, 2+, 3-, 3, 3+, 4-, 4, 4+, 5-, 5, 5+.

Carcass measurements

Several standard measurements were taken on the left half-carcass, according to the methodology described by De Boer *et al*. (1974). Variables recorded were: Carcass length (CL), hindlimb (thigh) length (HL), hindlimb width (HW) and chest internal width (CIW). The degree of maturity was assessed through ossification measurements: number of thoracic ossified processes, length of the first thoracic ossified process, length of the first thoracic process, breastbone ossification score (scale 1-7), pre-sternum ossification score (scale 1-4) and sacrum ossification score (scale 1-5)

Additional variables recorded were the area of *Longissimus* muscle or rib eye area (AREA) and kidney knob and channel fat (KKCF), a measure of internal fat expressed as a percentage of carcass weight. Acetate paper was placed on the surface of the sirloin at the level of the 7th rib, marking the area of the muscle with a glass marker. The area was determined by a planimeter.

Tissue and regional composition

Tissue and regional composition for muscle (M%), bone (B%), subcutaneous fat (SF%), intermuscular (IMF%) and total fat (TF%) were estimated from a sample from the 6th rib, taken at 24 hours *post mortem* of controlled chilling according to the method described by Robelin and Geay (1975).

Statistical analysis

Means and within year (residual) standard deviations have been computed for every breed - production system. The within year (residual) variances have been compared for the Spanish and French breeds by means of a Bartlett test. To represent the relationships between populations, a canonical analysis of populations (Cuadras 1996) based upon the Mahalanobis D distance has been performed.

For the study of the relationship between variables, data were previously corrected for the effect of the test-group since animals were fattened and slaughtered in two annual batches that might induced some environmental differences. The phenotypic variability was therefore

studied on the residuals (y_{ijk}) after fitting for the effects of breeds and years, and the interaction between both according to the linear model:

$$Y_{ijk} = \text{test-group}_{ij} + y_{ijk} = \text{breed}_i + \text{year}_j + \text{breed.year}_{ij} + y_{ijk}$$

The relationships between variables were estimated on all animals seeking for general biological association between traits. Correlation coefficients were calculated between all variables. These relationships were analysed by means of principal component analysis (PCA) that provided synthetic information on the joint variability of different variables of interest. Since some animals were lacking some of the trait measures, the PCA was performed on the correlation coefficient matrix calculated using all animals.

Linear regressions have been assessed within each breed-production system between carcass quality traits and daily weight gain, slaughter weight, and slaughter age as independent variables, although only significant slopes are shown.

All computations have been made by means of the SAS package (SAS 1990).

RESULTS AND DISCUSSION

Between and within breed-production system variability

Production traits

Breeds started fattening at different ages and weights (table 1). Fattening was similar to the standard system of the breed. Slaughter weight was decided by breed societies according to market demand. Among the Spanish breeds, slaughter weight was around 500 kg for AV, A-NI and Re breeds, BP and Pi were slaughtered at higher weights (550 kg), and AM and Mo presented the lowest weights at slaughter (450 kg). Among the French breeds, bulls from Au and Sal breeds were slaughtered above 700 kg, whereas the end point for Ga was 610 kg. Slaughter age was dependent upon the weight at slaughter and growth rate. That age ranged from 12 to 13 months in A-NI, BP and Pi, reaching a higher value for AM (almost 18 months). The French breeds were slaughtered at higher ages, particularly the Au and Sal breeds (24 and 19 months, respectively).

Quantitative growth (Fowler 1968) was assessed through the average daily weight gain. There were considerable variations among breeds regarding growth rate during fattening. The Spanish breeds, fattened on a high energy diet, can be classified into three main groups. Pi, A-NI and BP showed the highest growth, above 1.6 kg per day; AV and Re presented an intermediate daily weight gain (1.4 kg/day); and Mo and AM showed the lowest gains (1.11 and

1.03 kg/day). In comparison with these figures, French breeds showed an intermediate to low daily gain, due probably to the type of diet (maize silage *vs* concentrate) and the age of fattening. In all breeds, the growth during fattening followed a linear pattern. The residual variability expressed as a percentage of the mean (i.e. coefficient of variation) was higher for the Spanish breeds than for the French breeds. Regarding the first group, the figures ranged from 22% (Re) to 17.5% (AM), whereas the standard deviation for the French breeds ranged from 10.9 to 13.6% of the mean.

The results for growth for the Spanish breeds were slightly lower than those found by Albertí *et al*. (1999), but for A-NI, although the ranking was almost the same. The smaller daily weight gain could be due to the production in commercial conditions (differences in the diet and management) but also to the differences in the sample of animals studied.

Carcass quality

Carcass weight depends upon the decision on slaughter weight and also on dressing percentage (carcass yield). Pi, BP and AV reached a large hot carcass weight, around 330 kg, whereas the rest of the Spanish breeds presented carcass weight averages ranging between 250 and 285 kg. Two of the French breeds (Au and Sal) exhibited a carcass weight exceeding 400 kg; the carcass weight for Ga breed was however lower, 370 kg.

Three Spanish breeds, AV, Pi and BP, surpassed a carcass yield of 60%, AV excelling with a carcass yield of 63.6%, probably due to the double muscled condition of several of the young bulls sampled. The rest of the Spanish breeds presented a dressing percentage from 56.3 to 58.1%. Among the French breeds, the highest dressing percentage corresponded to the Ga breed (61.3%), the younger at slaughter, followed by Au and Sal. The residual variability was in general low and ranged from 2.5% to 4.9% of the mean, the differences between breeds being significant, both for the Spanish and French breeds. The variability of carcass yield was lower than the corresponding variability for slaughter weight.

Carcass yield was larger in this project than in Albertí *et al*. (1999), probably due to a different definition of carcass yield, but also to the fact that in our project the slaughter weight was higher for most of the breeds. The ranking, however, was similar. The positive correlation between slaughter weight and carcass yield was previously found by Andersen (1975), Geay (1978), and Osorio *et al*. (1995) who found a positive alometry coefficient of carcass yield regarding weight at slaughter, although More O'Ferral *et al*. (1989) failed to find such a tendency.

Results for carcass measurements and visual appraisal of conformation and fatness are presented in table 2. The Au and Sal French breeds presented the longer carcasses (length

close to 139 cm), in correspondence with their highest slaughter weight. These breeds were followed by Ga and Re breeds, with a carcass length slightly larger than 131 cm. The rest of Spanish breeds had an average carcass length close to 125 cm, being AM shorter with 121 cm, probably due to its low slaughter weight. Among the Spanish breeds, it is worth mentioning the high length of the Re, Mo and A-NI breeds relative to their weight at slaughter. Within breed variability was in general low, ranging from 2.1% to 4.6% of the mean for the Spanish breeds, and being below 2% in the French breeds.

Hind-limb length was similar for most of the Spanish breeds (78-80 cm), being shorter the average leg of AM and A-NI (75 and 75.9 cm respectively). It is worth mentioning again the long thigh of the Mo breed relative to its slaughter weight. French breeds presented longer hind-limbs than the Spanish breeds, with Sal breed having the higher value and Ga the lower. Within breed-system variability was in general low, ranging from 2.5 to 6.3% for the Spanish breeds and around 2% for the French breeds.

Notwithstanding the differences in slaughter weight, the averages for hind-limb thickness were very similar (27-30 cm), with the exception of AM breed (22.1 cm). French breeds showed an average hind-limb thickness similar to that of the Spanish breeds, however their higher slaughter weights. Variability for the Spanish breeds ranged between 5 to 10% with the exception of Mo breed (18.1%). French breeds showed variability lower than the Spanish breeds, approximately 3-4%.

With respect to the study of Albertí and Sañudo, our results were higher for carcass length and hind-limb thickness. Results for hindlimb length were difficult to compare due to the differences in slaughter weight; however, both studies confirm that Mo, Re and A-NI rustic type breeds exhibited larger thighs than BP, Pi and AV beef breeds.

Four Spanish breeds, the more rustic ones, were above 40 cm for chest internal width, whereas Pi and AV presented a lower value (36.4 cm in both cases). The average values for this variable were very similar between the French breeds, and always higher than the values of the Spanish breeds, probably due to their larger weight at slaughter. Within breed variability of chest internal width was in general low both for the Spanish and French breeds, ranging from 3.75 to 7.4% of the mean.

Very large differences between breeds were observed for the area of *Longissimus* muscle. Among the Spanish breeds, two breeds were above 60 cm^2 (AV and Pi) four breeds have an average area of around 40 cm^2 (A-NI, AM, Mo and Re), whereas the BP breed was intermediate (50.5 cm^2). French breeds presented intermediate to high values (54-61 cm^2), when compared to the Spanish breeds. Within breed variability was considerable, ranging from 13.4 to 24.5% in the Spanish breeds. The more variable breeds were those that presented the

higher values for average area. The variability of area in the French breeds was always lower than in the Spanish breeds, ranging from 5.6 to 13.2%.

Carcass internal (KKCF) fat included renal and pelvic fat. The lowest average values, expressed as a percentage of hot carcass weight, corresponded to AV and Pi breeds, whereas the highest ones corresponded to the A-NI and BP breeds (2.9 and 2.4% respectively). The French breeds presented averages above 2%, being 2.8 and 2.9% for the breeds Sal and Ga respectively. The variability was similar in all breed-production systems, around 0.6 – 0.7 percent units.

Carcass grading

Average conformation score exhibited large between breed-system differences regarding Spanish breeds but lower for the French breeds (table 2). The EUROP (+/-) score corresponding to the average of each breed-system is as follows: AM, R; AV, U+; A-NI, R+; BP, U; Mo, O+; Pi, U-; Re, R+; Au, U-; Ga, U-; and Sal, R. According to these results, the most conformed breed is AV, related to the double muscled condition of some of their animals, whereas Mo, A-NI and AM were the less conformed ones. The within breed-system variability of conformation scores was considerable, ranging from 8 to the 22% of the mean for the breeds BP and AV respectively. The higher variability of this last breed could be explained by the existence of a mixture of double muscled and non-double muscled animals in the sample. French breeds occupied an intermediate position regarding variability (around 15%).

For fatness score, large differences were found both between breeds and within breeds. The lower fatness scores corresponded to the AV and Pi breeds whereas A-NI, Mo and Re showed the higher scores, larger than 8. Similar values to the last ones were found in the French breeds. The residual variability reached very important values for some of the breeds, the coefficient of variation ranging from the 7.4% (Mo breed) to 53.6% (AV breed), with the remaining breed averages being scattered along that interval. It is worth mentioning that the within breed variability correlated inversely with fatness average.

Conformation score measures the thickness of muscle planes and fat in relation to the size of skeleton (De Boer *et al*. 1974). It is known that conformation score improves with the increase of carcass weight and degree of fatness (Andersen *et al*. 1984). Conformation is related with the ratio muscle/bone and muscle thickness, although correlation estimates are low (Kempster *et al*. 1982). Furthermore, conformation and fatness scores are subjective measures that will depend upon the competence of the observer. In general, our values for conformation were higher than those of Albertí *et al*. (1999), but for Mo and Pi breeds. No clear tendency could be observed for fatness, as some of the breeds showed higher values and some other

lower than those in the project of Albertí *et al*. (1999). A part of the differences could be due to the fact that the evaluator was not the same for all breeds. Besides that, the difference between the results of both projects could be attributed to differences in slaughter ages and weights, as well as in the energy content of the diet.

Tissue composition

Tissue composition average and variability values are presented in table 3. For muscle content, AV and Pi, as expected, showed the larger values (76 and 73%, respectively), followed by AM and BP. Comparatively, AV presented a 25% more muscle content than Re breed. The French breeds showed values (73-76%) in the higher range of Spanish breeds. Both for the Spanish and French breeds, the between breed differences were smaller for muscle content than for area of *Longissimus* muscle. This would suggest that the quantity of muscle outside the rib eye exhibited a large variability between breeds. Residual variability for muscle content, however, was low, with values ranging 4-6% and 3-4% for the Spanish and French breeds, respectively. The comparison of the within breed system variability of total muscle content in the 6th rib and of the *Longissimus* muscle suggests that there is a bigger possibility to select rib eye area than total muscle content. This is consistent with the fact that a better morphology is related with variations in the shape of the bone an muscles but not with their weights (Colomer 1982).

Regarding bone percentage, large differences were observed both between and within breeds. AV breed has less bone (14.1%) than Re and Mo breeds (18.4 and 21%, respectively), the other breeds occupying an intermediate position. The French breeds had intermediate values, i.e., 14-15% of bone. The differences in bone content, both between and within breeds can be related to differences in carcass weight, as bone content decreases as carcass weight increases (Andersen 1975; Robelin *et al*. 1978; Koch *et al*. 1979). Variability ranged from 11.2 to 18.6% of the mean in the Spanish breeds, being intermediate with respect to that range the French breeds.

Total fat was the variable presenting the largest variation both between and within breeds. Between breeds the range surpassed 100%. Whereas AV and Pi exhibited values of 8.5 and 9.9%, Re and A-NI had average values of 17 and 18.7%, respectively, the other breeds being intermediate (12-14%). The French breeds presented lower fat content, ranging from 7.3 for the Au bred to 10% (Ga and Sal breeds). The within breed variability was in general large, ranging from 11.8 to 38.8% in the Spanish breeds, with values inversely correlated to the average value. French breeds presented considerable variability, although it was similar among them (22-24%). It is worth mentioning that intermuscular fat percentage was always much larger than the subcutaneous fat content. This last variable, however, exhibited an extremely high

variation probably due to difficulties in removing the skin equally during dressing and also in performing an exact cut of the vertebra in all animals.

Our results were higher for muscle content (but for Pi) and lower for fat content (but for A-NI) than those of Albertí *et al*. (1999) predicted from the 10th rib. This difference is consistent with results of Oliván *et al*. (1999) who found that in comparison to the 10th rib, the 6th rib provides a better prediction of tissue composition, and also higher predictions for muscle percentage and lower for fat and bone contents.

Ossification study

The degree of ossification, related with the physiological age, is relatively homogenous, since the differences are in general not important (table 4). There are no differences between the lengths of the first ossified process and the number of completely ossified apophisis is minimum, being a little bigger in the Mo breed. This breed presents the smaller format and is presumably the most precocious one. Average values of esternum or presternum scores indicate a larger ossification ossification in the AV, AM and BP breeds.

As a general comment, it is worth mentioning that the variability was in general larger in the Spanish breeds than in the French breeds. This can indicate that the French breeds have been improved since long time ago by means of selection criteria clearly determined. On the contrary, the larger variability of Spanish breeds suggests that the selection programs might be at an initial stage. This variability, however, guarantees that the implementation of selection programs could be successful.

A second general comment is the parallelism among the results of this project with those found by Albertí *et al*. (1999). There were differences in the average values estimated in both projects. However, the main features that distinguish the breeds were maintained in conditions of commercial production and a wide range of slaughter weights.

Canonical analysis of populations

The spatial representation of the breed-systems is presented in two separate graphics corresponding to the Spanish and French populations (figure 3). The differences between breed-systems in both groups were highly significant, as measured by the Wilks' lambda. A first analysis (results not shown) including all populations showed a first canonical axis mainly determined by carcass weight, which masked the effect of other variables. As a consequence, we decide to perform two separate analyses.

Regarding the Spanish populations, the first canonical axis was determined mainly by the opposition of the proportion of muscle development and carcass compactness with fatness score and the proportion of fat estimated from the 6th rib. The second canonical axis was mainly determined by carcass size and in a lesser extent by hind-limb thickness. AV and Pi were the breeds with more muscle and less fat, whereas A-NI, Mo and Re were in the opposite side. BP and AM occupied an intermediate position.

At the same weight, the breeds of late maturity give more lean than the more precocious breeds and of lower growth (Fisher 1990). According to this criterion, our results allows to classify the Spanish breeds in three groups. AV and Pi would belong to the group of late maturity, A-NI, Mo and Re, would be early maturing breeds, whereas BP and AM, despite the small size of the last, will be of intermediate maturity.

In the French populations, the first canonical axis was related to size (carcass weight and carcass length), whereas the second axis was related to thigh compactness, as it opposed hind-limb length to hind-limb thickness. Au was the breed with the highest carcass weight and Ga exhibited the lowest. Sal occupied an intermediate position, showing the longer and thinner thigh.

Relationships among carcass characteristics

The principal component analysis (PCA) clearly showed sub-clusters of variables that were proximate (figure 4). Carcass conformation score, hind-limb width and rib eye area were closely correlated to each other, and also to dressing percentage. They represented the beef conformation quality. The different measures of fatness were grouped and opposed to muscle content in the 6th rib. The two carcass and thigh lengths measures were also close.

The first axis explained about 34% of the total variability of carcass characteristics among animals. It clearly discriminated animals according to their carcass fatness and conformation. There was an opposition between both groups of variables: animals with the better conformation were also the leaner. On that axis animals with longer carcasses tended to be lowly associated with a poorer conformation and fatter carcasses. The second axis explained a lower proportion of the total variability of carcass traits and was principally due to variability in bone content. That trait was clearly opposed to carcass conformation and muscle content and was associated with longer carcasses. It is well accepted that a better carcass conformation is related with lower bone content or higher muscle/bone coefficient (see revision of Sañudo and Campo 1997). That is specially true in animals not considered as double muscled were a superior conformation is related with higher muscle and lower fat content (Arthur 1995).

Regressions of carcass quality variables on production traits

Producers have the opportunity to handle several variables that potentially can influence carcass traits. This part of the project attempts to assess such effects through the regression of carcass variables on daily weight gain (DWG), slaughter weight and slaughter age.

Significant slopes of the regression of carcass weight on DGW were found for all the breeds but two (AV and Ga). Table 5 shows that such regression coefficients were always positive and ranged from 17.4 to 99.07. This means that in spite of that slaughter weight was theoretically fixed according to market demands, animals with higher growth tended to be slaughtered at higher weights in a consistent way across breeds.

Daily weight gain also affected negatively dressing percentage in AV, Mo, Re and Ga breeds. The slope was not significant for the rest of the breeds. This finding can be explained in the AV breed for its condition of double muscled breed, which associates low growth with large muscular development (Arthur 1995).

The relationship among carcass length and DWG followed a tendency similar to that described for carcass weight. The regression of hindlimb length on DWG was significant and positive in three breeds, AM, BP and Pi, although negative for A-NI. Hindlimb thickness was influenced by DWG in six breeds. In five cases (A-NI, BP, Mo, Pi, Sal) the slope was positive, indicating that higher growth was associated with thicker thighs. AV however showed a negative slope, consistent with previous results (Arthur 1995; Alberti *et al*. 1997) that demonstrate an inverse relationship between degree of muscularity and growth in double muscled breeds.

Chest internal width was not influenced by daily weight gain, but in AM and Ga breeds, in these breeds in an inconsistent way. A similar situation can be found regarding *Longissimus* muscle area. The influence of DGW on subjective scores, such as conformation and fatness, was in general not significant, although AM, Mo and Sal presented positive regression coefficients for conformation, and BP for fatness.

Tissue composition assessed from the 6th rib was in general not influenced by DWG, but in the case of AV breed. In this double muscled breed, in accordance with previous reports, a large growth is associated with less muscle content and more bone and fat contents (both intramuscular and total fat).

Slaughter weight did influence, as expected, carcass weight and longitudinal and thickness measurements. For the rest of variables, the slopes were either not significant or biologically irrelevant when significant (results not shown in tables). That is consistent with previous reports (e.g. Hammond 1996) since animals tend to increase mainly length and

thickness measures and less their height after the first year of life.

A similar situation was found for slaughter age. No association was found with carcass weight (except for Pi and Sal) and carcass measurements (results not shown in tables). A plausible explanation is that given a fixed end point for slaughter weight, larger ages correspond to lower growth rates, the result being an approximately constant final weight. Slaughter age was associated positively with chest internal width, although the slopes were very low. The slopes corresponding to the remaining variables were not significant or irrelevant.

CONCLUSSIONS AND IMPLICATIONS

Carcass of ten beef cattle breeds of Southwestern of Europe reared in their own production system have been fully characterized. There exist both large between breed and for some traits within breed variability.

The variability was in general larger in the Spanish breeds than in the French breeds. This can indicate that the French breeds have been improved since long time ago for carcass traits. On the contrary, the larger within breed variability of Spanish breeds suggests that the selection programs might be at an initial stage which suggest that the implementation of selection programs should be successful.

A clear parallelism among the results of this project and the results of the comparison of some of the Spanish breeds in the same fattening conditions and slaughter weight was revealed. In general, the average values of our project were larger. However, the main features that distinguish the breeds were maintained in conditions of commercial production and a wide range of slaughter weights.

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Figure 1. Geographical distribution of the breeds under study.

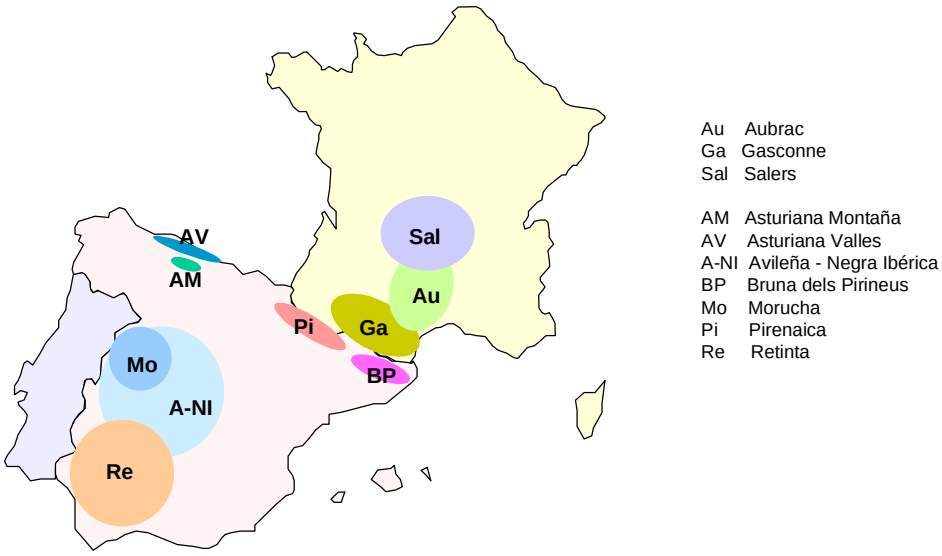


Figure 2. Ages and weights at slaughter in all breeds.

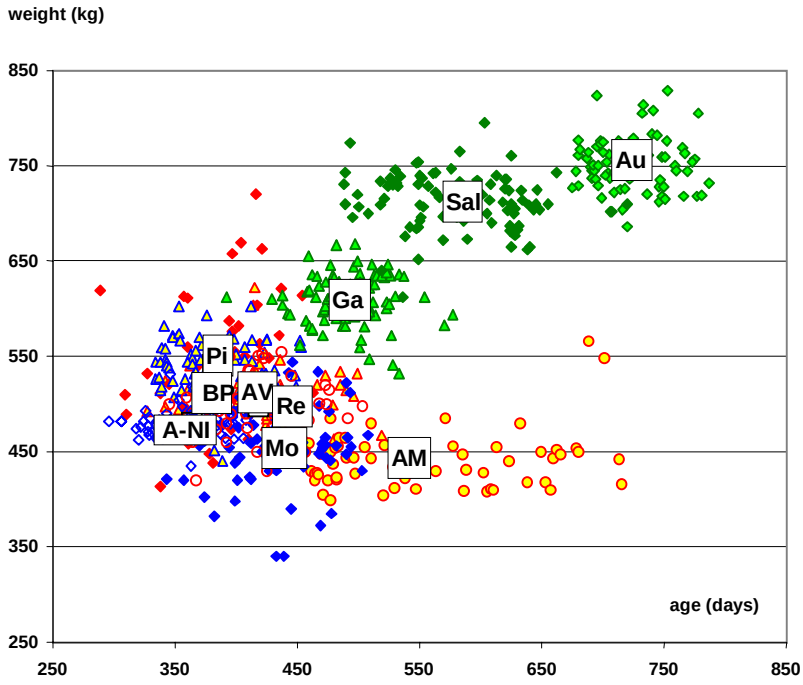
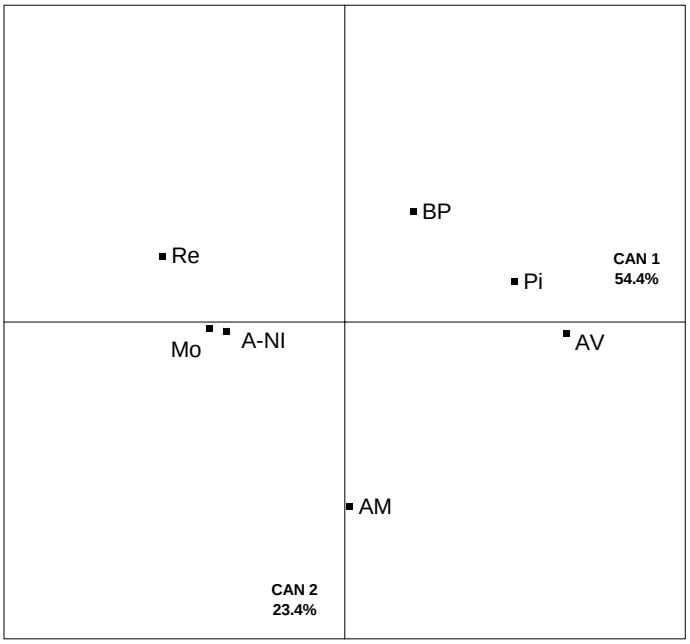


Figure 3. Canonical representation of Spanish and French beef cattle breeds.



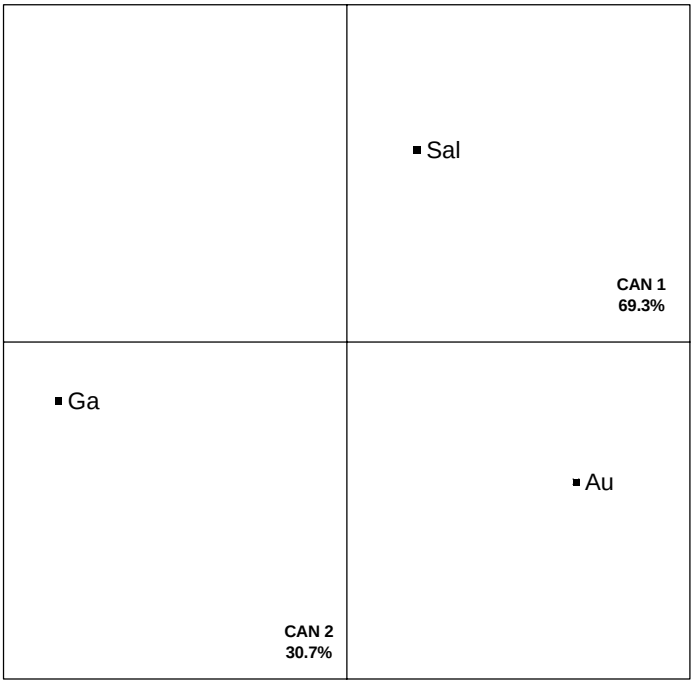


Figure 4. Relationships between carcass quality variables and synthetic indexes revealed through a Principal Component Analysis.

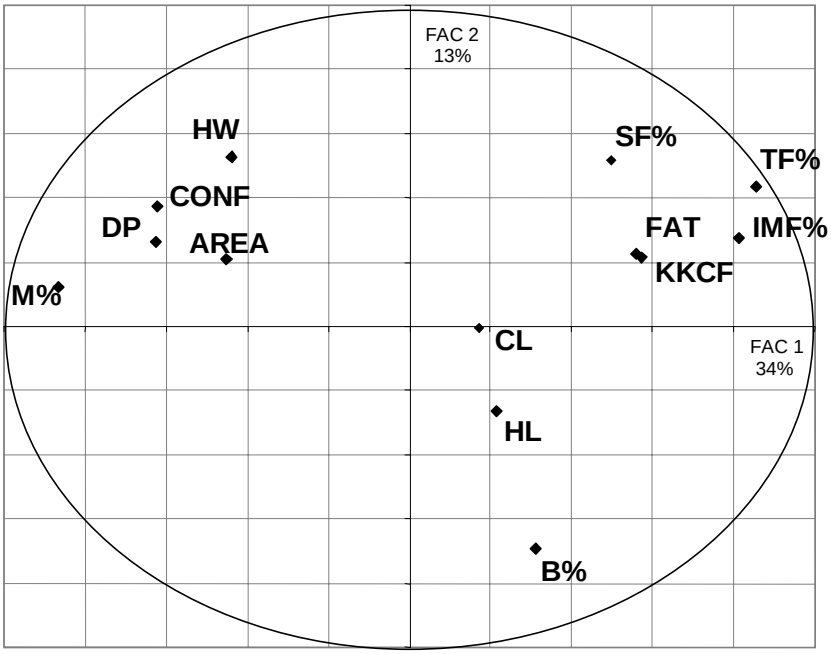


Table 1. Performance traits in ten local beef breed systems of the Southwest of Europe: means and residual standard deviations.

	AM	AV	A-NI	BP	Mo	Pi	Re	Au	Ga	Sal
N	70	70	71	75	70	55	68	79	82	92
On test age (days)	250.1 (32.2)	278.9 (22.8)	215.1 (28.3)	209.2 (27.1)	235.6 (28.5)	204.5 (40.0)	257.1 (38.0)	563.3 (20.3)	227.5 (23.8)	275.7 (24.3)
On test weight (kg)	153.5 (30.8)	316.9 (52.9)	235.4 (34.1)	268.1 (37.5)	232.8 (29.5)	261.3 (77.2)	274.7 (63.5)	553.1 (41.6)	250.0 (24.2)	325.3 (38.0)
Slaughter age (days)	541.0 (45.3)	415.7 (37.9)	363.6 (29.0)	380.6 (32.1)	438.9 (33.7)	382.7 (38.3)	417.7 (35.7)	722.8 (29.2)	492.3 (31.5)	582.1 (36.3)
Slaughter weight (kg)	443.7 (29.0)	509.2 (24.1)	481.0 (14.8)	541.6 (28.2)	458.6 (42.0)	551.7 (69.0)	498.2 (30.3)	753.3 (23.4)	610.4 (24.6)	714.1 (28.4)
Daily weight gain (kg/day)	1.03 (0.18)	1.41 (0.29)	1.64 (0.21)	1.63 (0.23)	1.11 (0.21)	1.65 (0.27)	1.41 (0.31)	1.25 (0.17)	1.37 (0.15)	1.29 (0.15)
Carcass weight (kg)	249.9 (21.4)	324.0 (21.5)	279.4 (9.6)	329.0 (19.3)	259.9 (25.4)	334.5 (44.0)	286.2 (17.6)	451.0 (16.3)	373.8 (17.1)	417.1 (19.2)
Dressing percentage	56.3 (2.2)	63.6 (3.1)	58.1 (1.5)	60.7 (1.5)	57.2 (2.1)	60.5 (1.6)	57.5 (1.9)	59.9 (1.8)	61.3 (2.2)	58.5 (1.6)

Table 2. Carcass measurement traits in ten local beef breed systems of the Southwest of Europe: means and residual standard deviations.

	AM	AV	A-NI	BP	Mo	Pi	Re	Au	Ga	Sal
Carcass length (cm)	121.4 (3.4)	123.9 (3.6)	126.7 (2.8)	126.2 (2.8)	125.4 (3.6)	126.7 (5.8)	131.6 (6.0)	139.3 (2.4)	132.4 (2.7)	138.9 (2.9)
Hind-limb length (cm)	75.0 (1.9)	78.0 (2.7)	75.9 (4.8)	79.1 (2.1)	79.6 (2.2)	79.9 (4.0)	78.6 (4.1)	86.1 (1.9)	82.3 (1.7)	89.8 (1.8)
Hind-limb thickness (cm)	22.1 (1.5)	26.9 (2.4)	27.9 (1.8)	30.6 (1.4)	29.1 (1.5)	29.2 (2.2)	29.3 (5.3)	32.0 (1.1)	29.2 (1.2)	29.3 (0.9)
Chest internal width (cm)	40.2 (2.1)	36.4 (2.7)	40.9 (1.9)	NM	42.6 (1.6)	36.4 (2.5)	43.1 (2.6)	45.6 (1.9)	45.7 (3.0)	47.3 (1.7)
Longissimus muscle area (cm^2)	43.4 (5.8)	65.0 (15.9)	43.9 (7.1)	50.5 (7.0)	41.9 (5.6)	63.6 (14.8)	38.9 (6.5)	61.0 (3.4)	55.1 (7.3)	54.9 (5.0)
KKCF (%)	NM	0.95 (0.6)	2.9 (0.6)	2.4 (0.6)	2.3 (0.6)	1.6 (0.5)	2.1 (0.7)	2.2 (0.6)	2.9 (0.7)	2.8 (0.7)
Conformation score	7.5 (1.3)	11.8 (2.6)	8.5 (0.9)	11.2 (0.9)	6.0 (1.3)	9.9 (2.0)	9.4 (1.3)	9.5 (1.5)	9.5 (1.5)	8.3 (1.1)
Fatness score	6.7 (1.2)	4.1 (2.2)	8.0 (0.9)	6.7 (1.5)	8.1 (0.6)	5.5 (1.7)	8.8 (1.2)	7.8 (1.4)	8.0 (1.0)	8.8 (1.6)

NM: Not measured

Table 3. Tissue composition estimated from the 6th rib of ten local beef breed systems of the Southwest of Europe: means and residual within year standard deviations.

	AM	AV	A-NI	BP	Mo	Pi	Re	Au	Ga	Sal
Muscle %	70.0 (3.6)	76.0 (4.8)	63.9 (2.8)	68.2 (3.5)	65.9 (2.8)	73.0 (3.7)	60.5 (3.9)	76.1 (2.3)	73.9 (3.1)	73.4 (2.5)
Bone %	15.8 (2.7)	14.1 (2.2)	15.3 (2.0)	16.3 (2.4)	18.4 (2.2)	16.1 (1.8)	21.0 (3.9)	15.4 (1.4)	14.5 (1.6)	15.2 (1.5)
Subcutaneous fat %	1.8 (0.7)	1.1 (0.7)	4.5 (1.3)	3.0 (1.0)	3.0 (0.8)	1.8 (1.1)	3.4 (1.4)	1.8 (0.6)	2.2 (0.8)	1.7 (1.0)
Inter-muscular fat %	10.6 (2.0)	7.3 (2.7)	14.2 (2.0)	9.7 (1.5)	11.0 (2.1)	8.1 (2.2)	13.6 (2.3)	5.8 (1.5)	7.8 (2.0)	8.3 (2.0)
Total fat %	12.4 (2.5)	8.5 (3.3)	18.7 (2.2)	12.7 (2.1)	14.0 (2.4)	9.9 (2.9)	17.0 (3.1)	7.6 (1.7)	10.1 (2.3)	10.0 (2.4)

Table 4. Ossification scores in seven Spanish beef cattle breeds.

	AM	AV	A-NI	BP	Mo	Pi	Re
N	70	70	71	75	70	55	68
Number of ossified apophisis	-	-	0.80 (0.35)	0 (0)	1 (0)	0.02 (0.13)	0 (0)
1st ossified process length (mm)	-	-	20.87 (1.16)	20.6 (1.16)	21.14 (1.52)	20.02 (1.35)	21.24 (1.98)
Breastbone ossification score	20.2 (1.02)	20.2 (1.31)	16.83 (0.89)	15.91 (0.79)	17.92 (1.25)	-	17.19 (1.87)
Esternum ossification score	2.2 (0.72)	2,06 (0.72)	1.03 (0.17)	2.28 (0.60)	1 (0)	1.64 (0.62	1.41 (0.61)
Presternum ossification score	1.97 (0.79)	1.7 (‘0.62)	1 (0)	2.04 (0.20)	1 (0)	1.36 (0.62)	1.48 (0.59)
Sacrum ossification score	-	-	2.10 (0.61)	2.81 (0.54)	2.64 (1.02)	-	3.54 (0.53)

Table 5. Slopes for each beef breed-system in the linear regressions relating carcass variables with the daily weight gain (DWG) as the independent variable.

	AM	AV	A-NI	BP	Mo	Pi	Re	Au	Ga	Sal
Carcass weight	33.0*		17.4**	35.4***	60.3***	99.1***	26.5***	23.3*		61.2***
Dressing percent		-4.5**			-3.2**		-1.6*		-5.5***	
Carcass length		2.7^{+}	4.1**	3.7**	4.9*	8.9**	5.6*	4.2**	5.8**	8.2***
Hind-limb length	2.7*		-9.0***	2.2*		5.4**				
Hind-limb thickness		-2.1*	3.0**	1.9**	3.3***	3.9***				2.4***
Chest internal width	-3.4*					2.4^{+}	1.7^{+}		8.1**	
L. muscle area						13.1^{+}		23.9*	-26.0*	
KKCF %		0.8***			0.7*				1.1*	
Conformation score	2.2*				2.0**	1.8^{+}				1.9*
Fatness score	1.4^{+}			1.8*			0.8^{+}			
Muscle %		-5.2**								
Bone %			2.3*		-3.3**					
Subcutaneous fat %		0.9***			1.3**	1.0^{+}	0.9^{+}			
Inter-muscular fat %		2.8*								2.7^{+}
Other %								0.4*		
Total fat %		3.7***			2.5*					

^{NS} not significant; $^{+}$ $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$