GENETIC EVALUATION OF THE TEXEL BREED IN URUGUAY: II. MEAT QUALITY TRAITS

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Abstract – The present study reports preliminary estimates of heritabilities of meat quality traits and genetic correlation among them and with carcass quality based on data on 424 lambs of the Texel Central Progeny Testing in Uruguay. Moderate heritabilities were estimated for color parameters, Warner-Braztler shear force (WBSF), intramuscular fat content (IMF) and fatty acid profile (percentage of saturates, monounsaturated and polyunsaturated fatty acids). Genetic correlations between fat thickness by ultrasound and GR were positive and moderate between them and with IMF. In contrast, rib eye area, which is an indicator of carcass muscling, was negatively correlated with IMF. This meat quality trait is relevant given its association with eating quality traits and nutritional value of lamb meat. The correlation between IMF with WBSF was -0.29 indicating that leaner lamb meat will tend to be less tender. On the other hand, genetic correlations of IMF with fatty acids percentages suggest that lower contents of IMF will have higher proportions of “healthier” fatty acid. Genetic improvement for higher meat yield is possible given the genetic variability estimated, but these preliminary associations suggest the need to take into account simultaneously meat quality traits to avoid any unfavorable effects, due to correlated responses.

I. INTRODUCTION

Genetic improvement can be an effective tool to improve productivity and product quality based on the exploitation of the genetic variability of the traits of interest. Within-breed selection of farm livestock may produce annual genetic gains in the range of 1 to 3% of the mean of the trait concerned. Although these rates of genetic gain seem small when considered on an annual basis, they are cumulative with continuous selection [1].

There is evidence of successful changes of lamb carcass composition by selection. For instance, genetic responses in lean composition were achieved in purebred terminal sire breeds on a national scale in the UK [2]. Genetic improvement largely depends on the magnitude of the genetic variance of the target traits. Ciappesoni *et al.* [3] reported significant genetic variances for *in vivo* and *post-mortem* carcass quality traits in the Texel breed in Uruguay. Estimates were of moderate to high magnitude, confirming that there is scope for genetic improvement.

Meat quality traits are also of relevance because of increasing consumers and retailers expectations. Nevertheless they have received little or no emphasis in breeding programs [4]. Difficulties to measures and high costs are two of the main reasons [5]. In the case of beef cattle and pigs, *in vivo* ultrasound assessments of intramuscular fat (IMF) have been used as a predictor of meat quality [5], although this image technology has not been applied in sheep.

IMF is a meat trait of interest due to its positive association with meat eating quality. Higher contents of IMF are linked to higher tenderness, flavor and juiciness, and therefore it has a positive general effect on palatability [6]. Values of 2 to 3% of IMF, as suggested by Savell and Cross [6], would indicate the possibility of achieving a palatable and healthy product. Genetic improvement of muscle content or lean yield may have negative effect on IMF content, and consequently on eating quality, if unfavorable associations are not taken into account at the time of selection.

Inclusion of new traits, such as meat quality into breeding programs requires knowledge of their heritabilities and of the genetic relationships among all characteristics of interest. This study presents estimates of genetic parameters for meat quality traits, and correlations among them and with carcass traits.

II. MATERIALS AND METHODS

Animals and information. Data was recorded at Central Progeny Testing (CPT) of the Texel breed in Uruguay that was established with the main aim of facilitating genetic linkage between studs-flocks, and allows genetic evaluation of carcass and meat quality traits. Information was recorded on 424 female and male lambs slaughtered between 2009 and 2013 with an average of 38.9 kg live weight and 3.5 of body condition. Details were provided by Ciappesoni *et al.* [3].

In this study we focused on meat color, tenderness, intramuscular fat content and fatty acid profile. Meat color was measured on the cut surface of the *Longissimus dorsi* with a Minolta Chroma meter (Model C-10). Parameters L* (relative lightness), a* (relative redness) and b* (relative yellowness) were assessed 60 minutes after the surface was exposed. Warner Braztler Shear Force (WBSF, kgF) was measured on *Longissimus dorsi* muscle after five days of aging. Intramuscular fat (IMF, %) was assessed at the *Longissimus dorsi* muscle by chemical extraction. A wide range of fatty acids were measured using Gas Chromatography, which were comprised in three traits: percentage of saturated fatty acids (SFA, %; C14:0, C16:0, C18:0, C20:0), percentage of monounsaturated fatty acids (MUFA, %; C14:1, C16:1, C18:1), and percentage of polyunsaturated (PUFA, %; C18:2(n-6), C18:3(n-6), C18:3(n-3), C20:2(n-9), C20:3(n-3), C20:3(n-6), C20:4(n-6), C20:5(n-3), C22:5(n-3), C22:6(n-3), CLA).

Some carcass traits were also included in this study. Selected characteristics were those likely to be used as selection criteria, including both *in vivo* (ultrasound) and *post-mortem* measurements. Traits recorded at the CPT, described by Ciappesoni *et al.* [3], were hot carcass weight (HCW, kg), and GR (mm) that measures tissue depth and is considered an indicator of carcass fatness. Scanning weight (SWT, kg), Rib Eye Area (REA, cm^2) and Fat Thickness (FT, mm) were also included. These traits are routinely *in vivo* recorded at an average age of 255 days and included in the genetic evaluation system. Ultrasound live traits (REA and FT) were collected using an Aloka SSD500 equipped with a 3.5 MHz, 17.2-cm linear array transducer (Aloka Co. Ltd., Tokyo, Japan), between the 12^{th} and 13^{th} ribs. Images were interpreted through the Biosoft Toolbox® offline interpretation software (Biotronics Inc. version 2.1).

Data analysis. Heritabilities (h^2) were estimated by univariate analysis performed with the GIBBS2F90 computer package [7]. For all traits, after preliminary analysis, it was decided to run a single chain of 1.000,000 iterations. The first 500,000 iterations were discarded and the sampling interval was 20, so that a total of 25.000 samples were kept to estimate features of posterior distributions. The posterior median, the Posterior Standard Deviation (PSD), and highest posterior density interval at 95% (95%HPD) of the estimated marginal posterior distribution were calculated. The animal model included year-flock, birth type, sex, dam age and age at slaughter (covariate) as fixed effects. Pedigree data comprised 982 animals including 23 sires and 318 dams.

Estimated Progeny Difference (EPD) for carcass and meat quality traits were estimated using the software BLUPF90 [7] and the previous heritability estimations. In addition, EPDs for SWT, REA and FT were computed with this database. Correlations between EPDs of the different traits for the lambs with *post-mortem* records (n=424) were calculated.

III. RESULTS AND DISCUSSION

Numbers of records, mean, standard deviation, as well as minimum and maximum values, are presented in Table 1. Differences in the volume of information are because data for SWT, REA and FT were of the national genetic evaluation database, whilst the other traits were recorded only on slaughtered lambs at the CPT. Lower number of records influences the magnitude of the posterior standard deviation, which implies the need of interpreting with caution some of the results. In general, estimates of these traits are less common in the literature because of the difficulties and high cost of data recording.

Estimates of heritabilities for meat quality traits were low to intermediate (0.12 to 0.27), whilst values for *in vivo* and *post-mortem* carcass traits were larger. Fresh meat color parameters L* and b* had moderate heritability estimates around 0.20, but a lower was obtained for a* (0.12). Results from other studies suggest that L* is the most heritable parameter with higher estimates compared to a* and b* ([4], [8]).

Table 1 Descriptive statistics for *in vivo* and *post-mortem* carcass and meat quality traits.

Trait	n(2)	Mean	sd	Min	Max
Sc. age (days) (1)	3109	259	27	182	316
SWT (kg)	3094	35.52	7.79	16.80	75.00
REA (cm^2)	3081	9.6	2.9	3.0	24.7
FD (mm)	3071	2.5	1.0	1.0	10.5
St. age (days) (1)	424	292	19	265	328
HCW (kg)	421	18.02	3.83	9.6	30
L*	394	36.93	3.52	26.39	45.17
a*	394	17.83	2.50	11.4	33.32
b*	394	6.86	2.24	2.87	14.49
WBSF (kg)	388	4.20	1.23	1.92	7.86
IMF%	389	2.8	0.98	0.65	6.59
SFA (%)	385	45.6	3.7	33.8	56.8
MUFA (%)	385	41.7	3.1	29.0	50.0
PUFA (%)	383	12.7	4.0	5.4	33.3

(1) Scanning (Sc.) and Slaughter (St.) age. (2) n, number of records; sd, standard deviation; Min, Max, minimum and maximum values.

Table 2 Estimated statistics of marginal posterior distributions of h2 estimates for *in vivo* and *post-mortem* carcass and meat quality traits.

Trait	Median	PSD	95%HPD_L	95%HPD_U
SWT (kg)	0.327	0.062	0.207	0.448
REA (cm^2)	0.191	0.049	0.102	0.291
FD (mm)	0.380	0.071	0.243	0.522
HCW (kg)	0.483	0.182	0.166	0.857
L*	0.205	0.115	0.020	0.447
a*	0.120	0.107	0.001	0.352
b*	0.194	0.148	0.003	0.507
WBSF (kg)	0.191	0.128	0.011	0.463
IMF (%)	0.185	0.126	0.000	0.442
SFA (%)	0.267	0.172	0.001	0.631
MUFA (%)	0.153	0.139	0.000	0.457
PUFA (%)	0.196	0.126	0.020	0.473

PSD: posterior standard deviation; 95%HPD: 95% highest posterior density interval Lower & Upper bound.

Moderate heritabilities for IMF and WBSF also indicate that are both responsive to genetic selection, which agrees with other studies, although higher heritabilities were reported by Karamichou *et al.* ([9], [10]), Lorentzen and Vangen [4] and Mortimer *et al.* [8]. In general, estimates of correlations agree about a negative association between both traits in sheep and also other species. In our studies the genetic correlation was negative and moderate (-0.23). Reports of heritablities of fatty acid profiles are very scarce, particularly in lamb meat although estimates in this studies are moderate, higher values were reported by Karamichou *et al.* [10].

Several correlations between EPD of carcass and meat quality trait were not statistically significant ($p>0.01$), and therefore are not reported (Table 3).The lack of significance may be due to the volume of data currently available. Nevertheless, many key associations were significant and provide relevant insight on possible implications of selection for carcass and meat quality traits, other attributes.

Table 3 Pearson correlation coefficients between EPD of animals with *post-mortem* records (n=424).

Correlation	SWT (kg)	REA (cm2)	FT (mm)	HCW (kg)	IMF (%)	GR (mm)
REA (cm^2)	0.46	-	-	-	-	0.32
FT (mm)	0.53	0.46	-	-	-	0.36
HCW (kg)	0.63	0.54	0.28	-	-	0.41
L*	0.22	0.16	NS	NS	NS	NS
a*	0.15	NS	NS	NS	0.23	NS
b*	0.27	0.20	NS	0.22	NS	NS
WBSF (kg)	NS	NS	-0.20	-0.13	-0.23	-0.29
IMF (%)	NS	-0.22	0.24	NS	-	0.14
SFA (%)	NS	NS	NS	NS	0.47	NS
MUFA (%)	NS	NS	0.15	NS	0.46	0.35
PUFA (%)	NS	NS	NS	NS	-0.65	-0.26

Note: NS: correlation non-statistically different from zero ($p>0.01$).

Live weight at the time of ultrasound scanning and REA were moderately correlated with color parameters (0.15 to 0.20). The few published estimates among these traits varied from zero to moderate positive values [8]. Our estimates indicate that selection for heavier and more muscling carcasses will increase all parameters, being lightness and redness the most relevant for consumer acceptability [11].

Given the positives correlations of FT (0.24) and GR (0.14) with IMF, increasing total content of fat carcass by selection on *in vivo* or *post-mortem* criteria will lead to higher levels of IMF. Estimates shows that REA is negative correlated with IMF. These values are in concordance with evidences that extreme selection for muscling or fatness had unfavorable effect on meat quality [12]. Because of the negative association with shear force (-0.23), higher IMF is linked to better tenderness. Other studies reported positive genetic correlation of IMF with other eating quality attributes such as juiciness and flavor [9].

Total carcass and IMF content is also relevant from a nutritional point of view. Genetic correlations between content of IMF and the percentages of SFA, MUFA and PUFA were of moderate magnitude in our study. The values were 0.47, 0.46 and -0.65, which indicates that decreasing IMF would increase the proportion of "healthier" fatty acids. Similar associations between IMF (predicted using muscle density by computed tomography) and fatty acid profile were reported by Karamichou *et al.* [10].

IV. CONCLUSION

Preliminary estimates of genetic parameters suggest that there is sufficient genetic variation for genetic improvement of lamb carcass and meat quality traits by selection. Furthermore, the estimates of genetic correlations provided very useful insight of some antagonistic associations. Nevertheless, even being of moderate magnitude there is scope for obtaining favorable genetic progress by the identification of suitable selection criteria and implementation of appropriate selection indexes.

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REFERENCES

1. Simm, G., Bünger, L., Villanueva, B. & Hill, W.G. (2005). Limits to yield of farm species: genetic improvement of livestock. In Yields of farmed species. Constraints and opportunities in the 21st century (eds Sylvester-Bradley, R. and Wiseman, J.), (pp. 123-141). Nottingham University Press.
2. MLC, 2002. Sheep Year Book 2002. Meat and Livestock Commission, Milton Keynes, UK.
3. Ciappesoni, G., San Julián, R., Navajas, E.A, Gimeno, D., Gutierrez-Zamit, E., Goldberg, V. & Brito, G. (2014). Genetic evaluation of the Texel breed in Uruguay: I. Carcass quality traits. In Proceedings 60th International Congress of Meat Science and Technology. 17-22 August 2014, Punta del Este, Uruguay.
4. Lorentzen, T.K. & Vangen, O. (2012). Genetic and phenotypic analysis of meat quality traits in lamb and correlations to carcass composition. Livestock Science 143(2-3): 201-209.
5. Simm, G., Lambe, N.R., Bünger, L., E.A. Navajas & Roehe, R. (2009). Use of meat quality information in breeding programmes. In J. Kerry & D. Ledward, Improving the sensory and nutritional quality of fresh meat (pp. 265-291), Cambridge, Woodhead Publishing.
6. Savell, J.W. & Cross, H.R. (1988). The role of fat in the palatability of beef, pork and lamb. In Committee on Technological Options to Improve the Nutritional Attributes of Animal Products, Designing Foods: Animal product options in the marketplace (pp. 345-355). Washington, DC, National Academy Press.
7. Misztal, I., Tsuruta, S., Strabel, T., Auvray, B., Druet, T. & Lee, D.H. (2002). BLUPF90 and related programs (BGF90). In: Proceedings 7th World Congress on Genetics Applied to Livestock Production, Montpellier, France. 28,07.
8. Mortimer, S.I., van derWerf , J.H.J., Jacob, R.H., Hopkins, D.L., Pannier, L., Pearce, K.L., Gardner, G.E., Warner, R.D., Geesink, G.H., Hocking Edwards,J.E., Ponnampalami, E.N., Ball, A.J., Gilmour, A.R. & Pethick, D.W. (2014). Genetic parameters for meat quality traits of Australian lamb meat. Meat Science 96: 1016–1024.
9. Karamichou, E., Richardson, R.I., Nute, G.R., Gibson, K.P. & Bishop, S.C. (2006a). Genetic analyses and quantitative trait loci detection, using a partial genome scan, for intramuscular fatty acid composition in Scottish Blackface sheep. Journal of Animal Science 84: 3228-3238.
10. Karamichou, E., Richardson, R. I., Nute, G. R., McLean, K.A. & Bishop, S.C. (2006b). Genetic analyses of carcass composition, as assessed by X-ray computer tomography, and meat quality traits in Scottish Blackface sheep. Animal Science 82: 151-162.
11. Khliji, S., van de Ven, R., Lamb, T.A., Lanza, M., & Hopkins, D.L. (2010). Relationship between consumer ranking of lamb colour and objective measures of colour. Meat Science 85: 224–229.
12. Hopkins, D.L., Fogarty, N.M. & Mortimer, S.I. (2011). Genetic related effects on sheep meat quality. Small Ruminant Research 101: 160-172