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Carcass conformation and joints composition of Churra Galega Bragançana and crossbred lambs by Suffolk and Merino Precoce sire breeds

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Abstract

Carcasses of Churro Galego Bragançano purebred and Suffolk and Merino Precoce crossbred lambs reared under three different conventional production system of northeast of Portugal were evaluated. Carcasses of male lambs had larger muscle *longissimus* width ($P < 0.05$) and smaller subcutaneous fat thickness ($P < 0.05$) than the female lambs. Carcasses of crossbred lambs had higher ($P < 0.05$) compactness indices and leg and shoulder proportion than Bragançano purebred. Suffolk crossed had lower KKCF proportion ($P < 0.05$) than Bragançano and Merino crossbred lambs. Male lambs had higher ($P < 0.05$) muscle proportion in almost all carcass joints than the female lambs. It was concluded that Suffolk can be used as sire breed in Bragançano ewes to produce lambs with leaner and more compact carcasses and better fat distribution, which allows slaughtering at higher slaughter weight, specially in more intensive production systems. Female lambs should be slaughtered at lower carcass weight than male lambs in order to produce carcasses with the same fattening degree.

Key words: sheep, crossbreeding, tissue composition, production system, local breed.

Resumen

Conformación y composición tisular de las piezas de la canal de corderos de raza Churra Galega Bragançana y sus cruces con Suffolk y Merina Precoz

Se evaluaron canales de corderos Churra Galega Bragançana y se cruzaron con Suffolk y Merino Precoz criados en tres sistemas de producción en el nordeste de Portugal. Los corderos machos presentaron el músculo *longissimus* más ancho ($P < 0.05$) y con menor ($P < 0.05$) espesor de grasa subcutánea que las hembras. Los corderos cruzados tuvieron mayores ($P < 0.05$) índices de compacidad y de proporciones de pierna y espalda que los Bragançanos. Los corderos cruzados Suffolk tuvieron menor proporción de grasa perirrenal que los Bragançanos y cruzados Merino. Los corderos machos tuvieron mayores ($P < 0.05$) proporciones de músculo, en casi todos los cortes, que las hembras. Se concluye que se pueden utilizar sementales Suffolk sobre ovejas Bragançanas para producir corderos con canales más magras, más compactas y con mejor distribución de la grasa, permitiendo sacrificios a pesos más elevados, especialmente en los sistemas de producción más intensivos. Las hembras deben ser sacrificadas con pesos más bajos para producir canales con el mismo estado de engrasamiento que los machos.

Palabras clave: ovino, cruzamiento, composición tisular, sistemas de producción, razas autóctonas.

Introduction

Carcass composition is determined by two principal factors: (1) animal intrinsic factors, as breed, sex and age; and (2) extrinsic animal factors, as production system and diet (Delfa and Teixeira, 1998). The carcass composition determines the meat yield and meat sensorial characteristics, in this way the carcasses economic value should be based on its composition. Delfa and Teixeira (1998) suggested that joints proportion and tissue composition of each joint should be the main criteria for carcass quality evaluation systems.

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Kempster *et al.* (1987a) pointed out that matching crossbreeding with production systems is the key factor in lamb production improvement, in order to get leaner carcasses at optimum slaughter weight and age. Kirton *et al.* (1995a) supported that to produce heavy lambs with higher meat content, producers must use rams with large mature size as sire breeds and raise lambs to higher slaughter weights. Several authors (Croston *et al.*, 1987; Kempster *et al.*, 1987a, 1987b; Teixeira *et al.*, 1996; Ellis *et al.*, 1997) have investigated the effect of crossbreeding in lamb carcass composition with promising results. Nevertheless little information is available on crossbreeding effect on carcass conformation measurements, carcass joints proportion and joints tissue composition.

The aim of this study was to evaluate the effect of two improved sire breeds, Suffolk and Merino Precoce, when mated to Churro Galego Bragançano local breed ewes, on carcass conformation measurements, joints proportion and in joints tissue composition in three different production systems in the northeast of Portugal.

Material and Methods

Animals

This study was carried out on 151 male and female lambs from Churra Galega Bragançana local breed and from crossbred lambs by Suffolk and Merino Precoce sire breeds. The study was conducted on three different farms (location), selected to cover a range of management systems and climatic conditions of the northeast of Portugal. The location 1 was the Escola Superior Agrária de Bragança Experimental Farm, with an intensive management, producing lambs off grass, with conserved forages and with access to commercial concentrates. The commercial concentrate used had the following composition (g kg^{-1}): crude protein 160, crude cellulose 90, ash 100, crude fat 40; and was offered *ad libitum* in a daily distribution until slaughter. The location 2 was an upland farm at 400 to 600 m high in the Montesinho Natural Park (Bragança), producing lambs off grass, some meadow hay, with a major period, in which stubbles are grazed. The location 3 was a hill farm above 800 m high in Montesinho Natural Park, producing lambs in extensive areas of hill grazing, with no feed supply, harsh weather during winter and grazing in oak areas of *Quercus pyrenaica* forest during summer.

In each location, two rams of each of the sire breeds, Churra Galega Bragançana, Suffolk and Merino Precoce, were used. The rams remained on the same farms throughout the 4 years of the experiment. The ewes from each location were assigned by random into three groups of 30 ewes for mating with the pairs of rams from each breed for a period of 30 days.

Lambs were reared under the conventional conditions of each farm and were slaughtered in order to attain the carcass weight between 8 to 14 kg, according to the conventional weight requirements for lamb consumption in Portugal (Alves and Teixeira, 1995).

Slaughter procedure and carcass measurements

Lambs were slaughter in the experimental slaughterhouse of the Escola Superior Agrária de Bragança, after 24 h fasting. Following slaughter, carcasses were weighed and cooled at 6ºC for 24 h. Carcass conformation measurements (Pálsson, 1939; Timon and Bichard, 1965) were taken on carcasses suspended in a gamble of constant width between legs (Fig. 1), described as follows: (i) carcass length (K, mm) – from the basis of the tail to the basis of the neck; (ii) leg

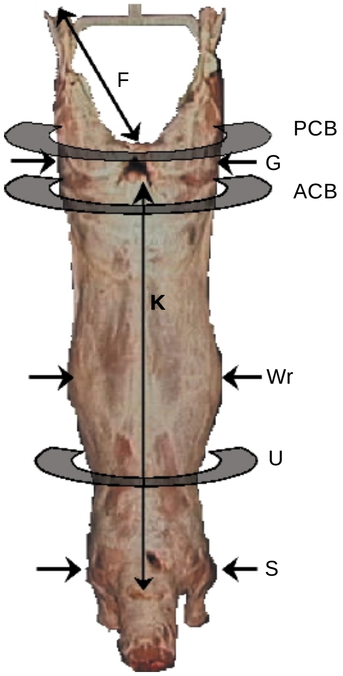

Figure 1. Schematic representation of the carcass conformation measurements.

length (F, mm) – the smallest distance from the perineum to the interior face of the tarsal-metatarsal articular surface; (iii) width of the buttocks (G, mm) – the width measured using the measuring calliper at the level of the proximal edge of the patellae; (iv) width of chest (Wr, mm) – the greatest width of the chest, (v) width of the shoulders (S, mm) – the greatest width of the shoulders, (vi) circumference of thorax (U, mm) – the circumference measured using a tape held horizontally around the thorax at the level of the caudal portion of the scapula; (vii) anterior circumference of buttocks (ACB, mm) – the circumference measured using a tape held horizontally around the buttocks at the level of the maximum width of the trochanter, (viii) posterior circumference of buttocks (PCB, mm) – the circumference measured using a tape held horizontally around the buttocks at the level of the caudal insertion. The leg compactness was evaluated by the relation between the width of the buttocks and leg length (G/F×100). The carcass compactness was evaluated by the relation between hot carcass weight (HCW) and carcass length (HCW/K, g cm^{-1}) as proposed by Pálsson (1939).

Carcasses were halved through the centre of the vertebral column and the kidney knob and channel fat (KKCF) was removed and weighed. The left side was divided into eight standardised commercial joints: leg, chump, loin, ribs, anterior ribs, shoulder, breast and neck according to the commercial jointing and cutting system (Fig. 2) of Estação Zootécnica Nacional (Calheiros and Neves, 1968). Some tissue measurements (Pálsson, 1939; Timon and Bichard, 1965) were taken on the surface of muscle *longissimus* at 12th-13th ribs level, with a metal ruler (Fig. 3), as follow: (i) maximum muscle width (A, mm); (ii) maximum muscle depth (B, mm); (iii) subcutaneous fat depth above B (C, mm). Each joint was dissected into muscle, subcutaneous fat, inter-muscular fat, bone and remainder (major blood vessels, ligaments, tendons and thick connective tissue sheets associated with some muscles).

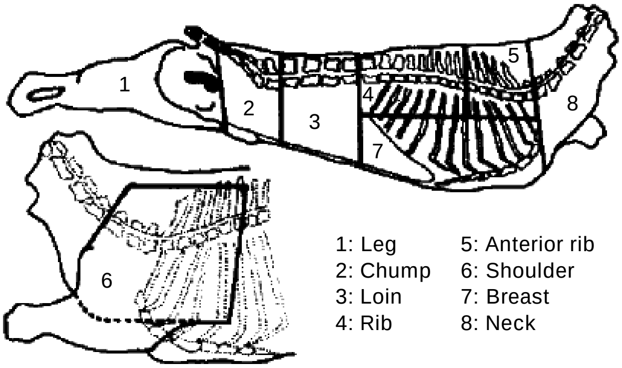

Figure 2. Schematic representation of the *Estação Zootécnica Nacional* carcass cutting system (Calheiros and Neves, 1968).

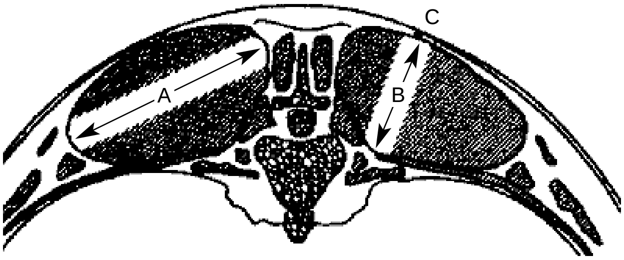

Figure 3. Schematic representation of muscle *longissimus* depth (B) and width (A) and subcutaneous fat thickness (C), adapted from Wood and MacFie (1980a).

Statistical analysis

The carcass data were analysed using the mixed models procedure (proc mixed) of SAS (1998) an used location (L), sire breed (SB) and sex (S) as fixed effects and their interaction. The data were adjusted to constant cold carcass weight as linear covariate (Steel and Torrie, 1982). A Tukey's pairwise test was used to examine the significance of the differences between locations, sire breed and sex least-square means.

Results

Carcass measurements

The least square means for treatments effects on carcass measurements are presented in Table 1. There was no significant ($P > 0.05$) effect of farm location on killing-out proportion, carcass perimeter measurements and on leg compactness indices. There was a significant effect of location on linear carcass measurements F ($P < 0.05$) and S ($P < 0.01$) without affecting ($P > 0,05$) other linear measurements. There was a location effect ($P < 0,05$) for *longissimus* muscle measurements, since carcasses from location 2 showed higher ($P < 0.05$) *longissimus* muscle width (A) than carcasses from location 1 and 3 and carcasses from location 3 presented higher ($P < 0.05$) subcutaneous fat thickness (C) than carcasses from the other two locations.

Sire breed did not affect ($P > 0.05$) killing-out proportion but changed the majority of other variables.

Table 1. Least squares means (± standard error) for treatment effects for killing-out proportion and carcass conformation measurements

	Location			Sire breed			Sex		Significance levels		
	1	**2**	**3**	**CGB**	**SU**	**MP**	**Male**	**Female**	**L**	**SB**	**Sex**
No. of lambs	48	37	66	79	28	44	99	52			
Killing-out (%)	46.6±0.40	47.2±0.40	48.0±0.56	48.0±0.37	47.2±0.59	46.7±0.37	46.3±0.32^{a}	48.3±0.42^{b}	ns	ns	***
Linear measurements (mm)											
K	775±4.8	761±4.8	768±6.7	785±4.5^{b}	763±7.1^{a}	756±4.5^{a}	771±3.9	766±5.1	ns	***	ns
F	300±2.2^{a}	306±2.2^{ab}	309±3.1^{b}	312±2.1^{b}	301±3.2^{a}	303±2.1^{a}	304±1.8	306±2.3	*	**	ns
G	232±1.2	234±1.2	233±1.7	232±1.2	234±1.8	233±1.1	233±1.0	234±1.3	ns	ns	ns
Wr	215 ±2.0	215±2.0	208±2.8	206±1.9^{a}	219±3.0^{b}	213±1.9^{b}	213±1.6	213±2.2	ns	***	ns
S	164±1.8^{a}	171±1.8^{b}	162±2.6^{a}	158±1.7^{a}	170±2.7^{b}	169±1.7^{b}	167±1.5	164±1.9	**	***	ns
Perimeter measurements (mm)											
U	677±3.8	684±3.8	681±5.4	678±3.6	678±5.6	687±3.6	683±3.1	678±4.1	ns	ns	ns
ACB	603±2.2	608±2.2	602±3.1	597±2.1^{a}	609±3.3^{b}	606±2.1^{b}	602±1.8	606±2.4	ns	**	ns
PCB	610±2.2	612±2.2	606±3.0	603±2.0^{a}	614±3.2^{b}	611±2.0^{b}	607±1.8	611±2.3	ns	**	ns
Tissues measurements (mm)											
A	54±0.58^{a}	56±0.59^{b}	53±0.82^{a}	53±0.55^{a}	56±0.87^{b}	54±0.55^{a}	56±0.47^{b}	53±0.62^{a}	*	*	**
B	28±0.54	27±0.55	27±0.77	26±0.52	28±0.81	28±0.51	27±0.44	28±0.58	ns	ns	ns
C	2.6±0.17^{a}	2.7±0.17^{a}	3.4±0.24^{b}	2.9±0.16	3.0±0.26	2.8±0.16	2.3±0.14^{a}	3.5±0.18^{b}	*	ns	***
Compactness indices											
HCW/K (g cm^{-1})	1.90±0.01	1.93±0.01	1.90±0.02	1.86±0.01^{a}	1.92±0.02^{b}	1.94±0.0^{b}	1.91±0.01	1.91±0.01	ns	*	ns
G/F	77.3±6.2	76.7±6.3	75.7±8.8	74.6±5.9^{a}	78.0±9.2^{b}	77.1±5.9^{b}	76.7±5.1	76.5±6.7	ns	**	ns

CGB: Churra Galega Bragançana. SU: Suffolk. MP: Merino Precoce. L: location. SB: sire breed. K: carcass length. F: leg length. G: width of the buttocks. Wr: width of chest. S: width of the shoulders. U: circumference of thorax. ACB: anterior circumference of buttocks. PCB: posterior circumference of buttocks. A: maximum muscle longissimus width. B: maximum muscle longissimus depth. C: subcutaneous fat depth above B. HCW/K: carcass compactness. G/F: leg compactness. ^{a,b,c} Means in the same row, within treatment, with different superscripts differ significantly ($P < 0.05$). * $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$. ns: not significant.

Carcasses of Churra Galega Bragançana pure-breed lambs showed higher length measurements (K, $P < 0.05$; F, $P < 0.05$) and lower width measurements (Wr, $P < 0.05$; S, $P < 0.05$) than crossbred lambs. Carcasses of Merino Precoce and Suffolk crossbred lambs showed higher perimeter measurements (ACB, $P < 0.05$ and PCB, $P < 0.05$). Carcasses of Suffolk crossbred lambs had higher *longissimus* muscle width (A, $P < 0.05$) and no differences ($P > 0.05$) were found among genotypes in B and C measurements. Churra Galega Bragançana pure-breed lambs presented lower carcass ($P < 0.05$) and leg compactness ($P < 0.01$) indices (PCQ/K and G/F) than crossbred.

Linear and perimeter measurements of carcasses were not affected ($P > 0.05$) by sex of lambs, although, carcasses of male lambs had greater muscle *longissimus* width and smaller ($P < 0.05$) subcutaneous fat thickness than the female lambs. Female lambs showed higher ($P < 0.001$) killing-out proportion than male lambs. Only the interaction location → sire-breed → sex for PCB measurement was significant ($P < 0.05$), which had little practical importance.

Carcass joints proportion

The least square means for treatment effects on carcass joints proportion are presented in Table 2. Carcasses from location 1 had higher ($P < 0.05$) leg proportion than carcasses from the other two locations. Carcasses from location 2 had higher ($P < 0.05$) KKCF proportion than the other two locations.

Carcasses of Churra Galega Bragançana pure-breed had lower leg ($P < 0.05$) and shoulder ($P < 0.05$)

Table 2. Least squares means (± standard error) for treatment effects for carcass joints proportion (g kg^{-1} carcass weight)

	Location			**Sire breed**			**Sex**		**Significance levels**		
	1	**2**	**3**	**CGB**	**SU**	**MP**	**Male**	**Female**	**L**	**SB**	**Sex**
Leg	253±1.6^{a}	245±1.6^{b}	244±2.2^{b}	244±1.5^{a}	250±2.3^{b}	249±1.5^{b}	253±1.3^{a}	242±1.7^{b}	***	*	***
Chump	88±1.2	88±1.2	88±1.7	88±1.2^{a}	84±1.8^{a}	92±1.2^{b}	87±1.0	89 ±1.3	ns	**	ns
Loin	116±1.8	117±1.8	120±2.6	119±1.7^{a}	121±2.7^{a}	112±1.7^{b}	113±1.5^{a}	121±1.9^{b}	ns	**	***
Ribs	71±0.9	70±0.9	71±1.3	71±0.9	70±1.4	70±0.9	69±0.8	72±1.0	ns	ns	ns
Middle neck	50±0.8	48±0.9	50±1.2	48±0.8	50±1.3	49±0.8	51±0.7^{a}	47±0.9^{b}	ns	ns	*
Shoulder	177±1.6	177±1.7	179±2.3	173±1.6^{a}	180±2.4^{b}	180±1.6^{b}	182±1.3^{a}	173±1.8^{b}	ns	**	***
Breast	123±1.3	120±1.3	124±1.9	122±1.3	122±2.0	123±1.3	122±1.1	123±1.4	ns	ns	ns
Neck	96±1.7	97±1.7	98±2.4	99 ±1.6	98 ±2.5	94±1.6	101±1.4^{a}	93±1.8^{b}	ns	ns	**
KKCF	24±1.2^{a}	29±1.2^{b}	25±1.7^{a}	30±1.1^{a}	22±1.8^{b}	27±1.1^{a}	20±1.0^{a}	33±1.3^{b}	*	***	***

CGB: Churra Galega Bragançana. SU: Suffolk. MP: Merino Precoce. L: location. SB: sire breed. KKCF: kidney knob and channel fat. ^{a,b,c} Means in the same row, within treatment, with different superscripts differ significantly ($P < 0.05$). * $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$. ns: not significant.

proportion than crossbred lambs. Carcasses of Merino Precoce crossbred lambs presented lower chump ($P < 0.05$) and loin ($P < 0.05$) proportion than Churra Galega Bragançana purebred or Suffolk crossbred lambs. Suffolk crossbred lambs showed lower KKCF ($P < 0.05$) proportion than Bragançano purebred and Merino Precoce crossbred lambs.

Carcasses of female lambs had lower loin ($P < 0.05$), middle neck ($P < 0.05$), shoulder ($P < 0.05$) and neck ($P < 0.05$) proportions than male lambs; on the other hand, they presented higher loin ($P < 0.05$) and KKCF ($P < 0.05$) proportions. Only the interaction location → sire-breed for neck joint proportion was significant ($P < 0.05$) and is of little practical importance.

Carcass joints composition

The least square means for treatments effects on carcass joints proportion are presented in Table 3. Lambs from location 1 presented higher muscle proportion in all carcass joints but significant ($P < 0.05$) differences were only detected in leg, chump, loin, middle neck and in breast. Lambs from location 2 had lower ($P < 0.05$) subcutaneous fat proportion in the ribs than the lambs from the other two locations. Carcasses of lambs from location 3 showed higher inter-muscular fat proportion ($P < 0.05$) in some carcass joints, especially evident in chump, loin ($P < 0.05$) and breast ($P < 0.05$).

Carcasses of Suffolk crossbred lambs had lower ($P < 0.05$) muscle proportion on middle neck and no differences ($P > 0.05$) were found in all others joints. Suffolk crossbred lambs had lower ($P < 0.05$) subcutaneous fat proportion in the chump and in the loin carcass joints. No differences ($P < 0.05$) were found in intermuscular fat between sire breeds.

Male lambs showed higher ($P < 0.05$) muscle proportion in all carcass joints than female lambs, except for the middle neck joint where no differences ($P > 0.05$) were found. Female lambs showed a higher ($P < 0.05$) subcutaneous fat proportion in the loin and in the ribs. Female lambs had higher ($P < 0.05$) intermuscular fat proportion and lower ($P < 0.05$) bone proportion in all carcass joints than the male lambs, however, no differences ($P > 0.05$) were found in bone proportion of loin.

Discussion

Carcass measurements

The killing-out proportion has a great importance in live animal commercialisation and is highly conditioned by food type and by gastrointestinal contents at slaughter time and, also, by fattening grade. The positive association between the fattening grade and killing-out proportion was already described by Kirton *et al.* (1995b). The highest killing-out proportion presented by lambs from location 3 can be explained by their higher fattening degree, which can be confirmed by the greater subcutaneous fat thickness (+0.7 mm), probably due to their slower growth rate, which led to a higher degree of maturity at slaughter, as described by Kirton and Morris (1989).

Table 3. Least squares means (± standard error) for treatment effects for carcass joints tissue composition ($g\ kg^{-1}$ joint weight)

	Location			**Sire breed**			**Sex**		**Significance levels**		
	1	**2**	**3**	**CGB**	**SU**	**MP**	**Male**	**Female**	**L**	**SB**	**Sex**
Leg											
M	685±3.4^{b}	670±3.5^{a}	670±4.8^{a}	675±3.3	675±5.1	674±3.2	680±2.8^{b}	670±3.7^{b}	**	ns	*
SF	49±3.2	46±3.2	56±4.5	45±3.0	51±4.8	54±3.0	47±2.6	53±3.4	ns	ns	ns
IF	82±4.4	96±4.4	80±6.2	95±4.1	82±6.5	90±4.1	82±3.5^{a}	96±4.6^{b}	ns	ns	*
B	183±2.0	187±2.0	185±2.8	184±1.9	188±2.9	182±1.9	189±1.6^{b}	181±2.1^{a}	ns	ns	**
Chump											
M	613±5.8^{b}	598±5.8^{ab}	585±8.1^{a}	592±5.5	614±8.6	592±5.4	613±4.7^{b}	584±6.1^{a}	*	ns	**
SF	85±6.3	94±6.3	81±8.9	91±6.0^{ab}	72±9.4^{a}	101±5.9^{b}	80±5.1	95±6.7	ns	*	ns
IF	167±7.7^{a}	176±7.7^{ab}	204±10.8^{b}	184±7.3	184±11.4	179±7.2	169±6.2^{a}	196±8.2^{b}	**	ns	**
B	135±3.0	132±3.1	125±4.3	133±2.9	134±4.5	126±2.9	135±2.5^{b}	126±3.2^{a}	ns	ns	*
Loin											
M	650±7.0^{b}	620±7.1^{ab}	601±9.9^{a}	625±6.6	632±10.4	622±6.6	662±5.7^{b}	591±7.5^{a}	***	ns	***
SF	75±4.4	70±4.4	84±6.2	76±4.2^{ab}	65±6.6^{a}	87±4.2^{b}	65±3.6^{a}	88±4.7^{b}	ns	*	***
IF	162±6.5^{a}	192±6.6^{b}	216±9.2^{b}	194±6.2	196±9.7	186±6.2	164±5.3^{a}	220±6.9^{b}	**	ns	***
B	107±3.6	109±3.7	98±5.1	104±3.5	106±5.4	104±3.4	109±3.0	100±3.9	ns	ns	ns
Ribs											
M	538±6.1	532±6.2	529±8.6	532±5.8	532±9.1	524±5.8	549±5.0^{b}	511±6.5^{a}	ns	ns	***
SF	92±5.2^{ab}	76±5.3^{a}	93±7.4^{b}	90±4.9	86±7.7	88±4.9	69±4.2^{a}	108±5.6^{b}	*	ns	***
IF	186±5.6	203±5.6	202±7.9	198±5.3	185±8.3	208±5.3	185±4.6^{a}	208±6.0^{b}	ns	ns	**
B	181±4.1	186±4.1	180±5.7	177±3.9	191±6.0	180±3.8	193±3.3^{b}	172±4.3^{a}	ns	ns	***
Middle neck											
M	606±6.7^{b}	599±6.7^{b}	568±9.4^{a}	606±6.3^{b}	565±9.9^{a}	603±6.3^{b}	591±5.4	592±7.1	**	**	ns
SF	188±5.9^{a}	200±5.9^{ab}	220±8.3^{b}	197±5.6	216±8.7	195±5.5	194±4.8^{a}	211±6.3^{b}	**	ns	*
IF	206±4.3	206±4.3	212±6.0	198±4.0^{a}	219±6.3^{b}	207±4.0^{ab}	215±3.5^{b}	201±4.5^{a}	ns	*	*
Shoulder											
M	619±3.8	618±3.8	612±5.4	624±3.6	612±5.7	613±3.6	624±3.1^{a}	609±4.1^{b}	ns	ns	**
SF	49±2.9	51±2.9	52±4.0	47±2.7	53±4.3	51±2.7	48±2.3^{a}	53±3.1^{b}	ns	ns	ns
IF	136±6.9	140±6.9	139±9.7	127±6.5	146±10.2	142±6.5	125±5.6^{a}	152±7.3^{b}	ns	ns	**
B	196±2.8	200±2.8	196±3.9	201±2.6^{b}	199±4.1^{ab}	192±2.6^{a}	204±2.3^{b}	191±3.0^{a}	ns	*	***
Breast											
M	501±6.9^{b}	489±6.9^{ab}	461±9.7^{a}	491±6.5	479±10.2	480±6.5	501±5.6^{b}	466±7.3^{a}	**	ns	***
SF	42±2.9	42±3.0	33±4.2	41±2.8	32±4.4	44±2.8	38±2.4	40±3.1	ns	ns	ns
IF	306±7.8^{a}	315±7.9^{a}	356±11.0^{b}	318±7.4	330±11.6	329±7.3	303±6.3^{a}	348±8.3^{b}	**	ns	***
B	150±2.7	154±2.7	150±3.8	150±2.5^{ab}	160±4.0^{b}	146±2.5^{a}	158±2.2^{b}	145±2.8^{a}	ns	*	***
Neck											
M	554±6.1	548±6.1	546±8.6	551±5.8	553±9.0	545±5.7	568±4.9^{b}	531±6.5^{a}	ns	ns	***
SF	36±2.5	40±2.5	45±3.5	38±2.4	40±3.7	42±2.3	41±2.0	39±2.7	ns	ns	ns
IF	239±7.4	245±7.4	247±10.4	249±7.0	243±11.0	240±7.0	216±6.0^{a}	272±7.9^{b}	ns	ns	***
B	171±4.3	167±4.4	162±6.1	163±4.1	164±6.5	173±4.1	175±3.5^{b}	159±4.6^{a}	ns	ns	***

CGB: Churra Galega Bragançana. SU: Suffolk. MP: Merino Precoce. L: location. SB: sire breed. M: muscle. SF: subcutaneous fat. IF: intermuscular fat. B: bone. ^{a,b,c} Means in the same row, within treatment, with different superscripts differ significantly ($P < 0.05$). * $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$. ns: not significant.

As expected, female lambs showed higher killing-out proportion than male lambs, due probably to their higher fattening degree when compared at the same carcass weight (Wood *et al.*, 1983; Kirton and Morris, 1989; Jeremiah *et al.*, 1997c; McClinton and Carson, 2000) as confirmed by their larger subcutaneous fat thickness and KKCF proportion.

The farm location effect on carcass conformation measurements, when compared at same cold carcass weight, was small and not important. The longest and thinnest carcasses presented by Churra Galega Bragançana lambs are in accordance to the expected results, since this is a local breed without selection pressure for carcass conformation.

Since Pálsson (1939) pioneer work carcass compactness indices have been used as objective indicators of carcass conformation. In this way, shorter and thicker carcasses show a more compact aspect, which can be advantageous, since it can improve consumer attractiveness to joints with higher muscle area, as pointed out by Hopkins *et al.* (1997). These authors observed that better conformation is associated to higher muscle:bone ratio. Nevertheless, the opposite was observed in this study, where Churra Galega Bragançana purebred lambs showed higher muscle: bone ratio, as previously published by Teixeira *et al.* (1996). These differences could be explained by the lower carcass weight used in this study. Kirton and Pickering (1967) did not find differences in meat content and in joint proportions between lambs with compact (bloky) or poor (leggy) conformation. This seems to be confirmed by this study results, since sire breeds differences observed in compactness indices do not produce great differences in carcass joints proportion.

The higher muscle *longissimus* width presented by Suffolk crossbred carcasses can be an advantage, since it is associated to higher muscle area, which in turn is closely associated to carcass conformation. Joints with higher muscle area have better visual appreciation and higher consumers acceptability, as pointed out by Kempster (1983). On the other hand, several authors (Kirton *et al.*, 1995b; Hopkins *et al.*, 1997; Hopkins and Fogarty, 1998) found no differences in muscle *longissimus* area among carcasses from different sire breeds, mainly between Suffolk and Texel crosses. Kirton *et al.* (1995b), in a 10 years study in New Zealand, observed significant differences in muscle *longissimus* area among lambs of different sire breeds, when data were corrected to the same carcass weight.

The muscle *longissimus* width were 3 mm larger on male lamb carcasses than on female carcasses, which is contrary to Jeremiah *et al.* (1997a), who found no sex differences in this measurement.

The larger subcutaneous fat thickness presented by female lambs, when compared at the same carcass weight, supports the theory that male lambs, due to their higher growth rate, have less subcutaneous fat than female lambs as widely described in the bibliography (Jones, 1982; Kirton and Morris, 1989; Teixeira *et al.*, 1996; Jeremiah *et al.*, 1997a; McClinton and Carson, 2000).

Carcass joints proportion

The higher KKCF proportion for Churra Galega Bragançana pure-breed carcasses seems to confirm the theory that hill or ewe-type breeds have more internal body fat than specialised meat type breeds, as suggested by Kempster and Cuthberson (1977), Wood *et al.* (1980b) and Teixeira *et al.* (1996) and that crossbreeding can improve the fat distribution in carcasses.

Sire breed influenced the carcass joint proportion; however, the differences found, apart from being statistically different, were small. These results are in agreement to those attained by Hopkins and Fogarty (1998) who found significant differences in carcass joint proportion in a study with Texel, Poll Dorset, Border Leicester and Merino sire breeds mated to Border Leicester × Merino and Merino ewes. Cruickshank *et al.* (1996) also found differences between sire breeds in the higher valuable carcass joints. Fraser and Stamp (1989) attributes the breed differences for joint proportion to the higher lumbar and sacred vertebras growth in specialized meat type breeds.

Male lambs had higher leg and forequarter joint proportions than female lambs, mainly for neck and shoulder joints. On the other hand, they had lower KKCF and loin proportion than female lambs. These results seem to confirm those from Carpenter *et al.* (1969), who verified that female lambs and wethers produce carcasses with higher hindsaddle proportion than male lambs, probably as a result of the highest shoulders proportion in male lambs. On the other hand, Jeremiah *et al.* (1997c) found no significant sex differences on hindsaddle and longsaddle proportion; although these authors removed the KKCF fat from the carcass. In the same way, Jeremiah *et al.* (1997c) found no consistent differences in shoulders proportion (corresponding in our cutting system to the shoulder plus neck joints) among genders (male, female and wethers) due the different chronological age at slaughter.

Carcass joints composition

The differences between farm locations for bone proportion were almost inexistent. However, lambs from farm location 1 presented higher muscle proportion in all carcass joints and had lower fat proportion, namely intermuscular fat in loin, middle neck and breast joints. These results are in agreement with those reported by Teixeira *et al.* (1996) and could be explained by the differences in growth patterns of lambs from different locations.

Sire breed effect on carcass joints composition was small which is in agreement with the previous results presented by Teixeira *et al.* (1996) for carcass composition. However, superiority in subcutaneous and intermuscular fat deposition in Merino and Suffolk crossbred lambs were observed. These results seem to confirm the theory that the distribution of individual body fat depots varies considerably among breeds when compared at same carcass weight (Kempster, 1983; Butler-Hogg, 1984).

Kempster (1983) mentioned that the muscle weight distribution is a trait with little variation. However, Kirton *et al.* (1995b) observed higher muscle proportion in Suffolk lambs than in Merino lambs, when compared at same carcass weight. When compared at equal carcass weight, animals with lower mature weight are fatter than animals with high mature weight (Kirton *et al.*, 1995a, 1995b). In our study, the small differences observed among sire breeds can be explained by the low carcass weight, since more evident differences might be expected at higher carcass weights.

Tissues proportion was highly conditioned by sex in all carcass joints. Male lambs had higher muscle and bone proportion, while female lambs presented higher subcutaneous and intermuscular fat proportion. These results are in accordance with previous results published by Jeremiah *et al.* (1997b) and McClinton and Carson (2000). Butler-Hogg (1984) and Ellis *et al.* (1997) found small differences in the carcass characteristics between sex, although the comparison was made at equal subcutaneous fat thickness and not at an equal carcass weight as in this study.

As conclusions, on the basis of the observed results we can affirm that crossbreeding, in particular with Suffolk as sire breed, could be a strategy to produce more compact and leaner carcasses, with better fat distribution. Therefore, it allows slaughtering at higher carcass weight, especially in more intensive production systems. These results clearly indicate that female lambs should be slaughtered at lower weight than male lambs in order to produce carcasses with the same fattening grade.

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