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Influence of breed, milk diet and slaughter weight on carcass traits of suckling kids from seven Spanish breeds

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Abstract

This experiment aimed to describe the influence of production system on the following characteristics from seven Spanish goat breeds: carcass weight, dressing percentage, head weight, viscera weight, kidney fat weight, fatness score, carcass length, leg length, rump perimeter, rump width, kidney fat colour and tissue composition of shoulder. Experiment involved 201 male, single-birth suckling kids from five meat and two dairy breeds. Animals from meat breeds were slaughtered at two targets carcass weights (light, 4 kg; heavy, 7 kg). In dairy breeds, half of the animals were reared with dam's milk and the other half with a milk replacer and all of them were slaughtered at light weight (4 kg). Statistics consisted in two GLM, means for each variable, a PCA to study relationships between variables and a discriminant analysis to compare breeds. In dairy breeds, breed had greater influence than milk diet, with breed effect being particularly strong for kids that were fed with natural milk. In meat breeds, slaughter weight was more important than breed and many significant interactions were found between both effects. All carcass traits were closely related to each other and to slaughter weight. Slaughter weight was also positively related to dressing percentage and to fatness degree. Discriminant analysis explained 76.1% of variability and separated dairy breeds, with well-fattened, medium-shaped carcasses, from meat breeds, with good conformations and medium fatness degrees. Hence, carcass traits were able to group breeds by diary or meat type.

Additional key words: carcass tissue composition; fat colour; goat; morphometric measurements.

Resumen

Influencia de la raza, tipo de lactancia y peso al sacrificio sobre las características de las canales de cabritos lechales de siete razas españolas

El experimento describe la influencia del sistema de producción sobre las siguientes características de la canal de cabritos de siete razas españolas: peso de canal, de la cabeza, de las vísceras y de la grasa renal, rendimiento a la canal, engrasamiento, longitud de la canal y de la pierna, perímetro y anchura de la pierna, color de la grasa renal y composición tisular de la espalda. Se utilizaron 201 cabritos machos, de parto simple, de cinco razas cárnicas y dos lecheras. Los animales de las razas cárnicas se sacrificaron a dos pesos de canal objetivo (ligeros, 4 kg; pesados, 7 kg). En las razas lecheras, la mitad de los cabritos se alimentaron con leche materna y la otra mitad, con un lacto-reemplazante y todos los animales fueron sacrificados al peso ligero (4 kg). En las razas lecheras, la raza fue más importante que el tipo de lactancia, especialmente en los cabritos alimentados con leche natural. En las razas cárnicas, el peso tuvo mayor influencia que la raza, aunque se observaron numerosas interacciones entre ambos efectos. Todas las variables estuvieron estrechamente relacionadas entre sí y con el peso al sacrificio y éste ultimo estuvo además positivamente

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Abbreviations used: BA (Blanca Andaluza breed); BC (Blanca Celtibérica breed); GLM (General Linear Model); MA (Malagueña breed); MO (Moncaína breed); MU (Murciano-Granadina breed); NE (Negra-Serrana breed); PCA (principal component analysis); PI (Pirenaica breed).

correlacionado con el rendimiento a la canal y el grado de engrasamiento. El análisis discriminante explicó un 76,1% de la variabilidad encontrada y separó las razas lecheras, bien engrasadas y con canales de tamaño medio, de las razas cárnicas, con buenas conformaciones y un grado intermedio de engrasamiento. Por lo tanto, las características de la canal permiten agrupar las razas en función de su propósito productivo.

Palabras clave adicionales: composición tisular de la canal; color de la grasa; ganado caprino; medidas lineales de la canal.

Introduction

Goats are regarded worldwide as an important species due to their contribution to the development of both rural zones and people (Dubeuf *et al.*, 2004). The EU accounts for 1.9% of total annual world production of goat meat (FAO, 2008; http://faostat.fao.org) and the Mediterranean countries are the major producers in the EU. In 2009 Spain had around 2.3 million heads of goat (FAOSTAT, 2010; http://faostat.fao.org), 68% of which corresponded to dairy breeds (MARM, 2011; http://www.magrama.gob.es/es/ganaderia/estadisticas). Spain's 22 indigenous goat breeds (MARM, 2011; http://www.magrama.gob.es/es/ganaderia/estadisticas) have specific genetic and are reared in a wide diversity of ecosystems, depending on the breed: dairy breeds are generally reared intensively whereas meat breeds are primarily reared extensively or semi-extensively. Regardless of the breed, the most frequent goat product in the Spanish market is suckling kid with a liveweight of 10-11 kg and carcass weight of 5-7 kg (Marichal *et al.*, 2003), which is perceived by consumers to be a high-quality meat.

Given that goat meat has an insignificant position in terms of overall farm production, little attention has been paid to it and, hence, Spanish and international literature on goat carcass and meat quality is very scarce. This lack of knowledge of the particularities of the species has placed many Spanish breeds in a situation where they are on the brink of extinction, posing a real risk of losing valuable genetic heritage. It was therefore considered fundamental to study carcass and meat characteristics of the different Spanish goat breeds, analysing the specific characteristics of each breed and highlighting their productive potential.

Factors influencing carcass characteristics have been widely studied in other species, such as lamb (Sañudo *et al.,* 1997; Santos-Silva *et al.,* 2002; Pérez *et al.,* 2007, Carrasco *et al.,* 2009) and cattle (Piedrafita *et al.,* 1999, 2003; Albertí *et al.,* 2000, 2001, 2007; Purchas *et al.,* 2002) and has been shown that breed is an important source of variation. Behind this, weight influences the development pattern of the animals and hence, the amount of edible meat (Vergara *et al.,*1999; Albertí *et al.,* 2001, 2005; Marichal *et al.,* 2003; Pérez *et al.,* 2007; Peña *et al.,* 2007). Traditionally, in Spain kid goats are reared with their dams but this practice decreases the availability of milk for cheese production. Therefore, dairy goat farmers remove the kids from their dams at a very young age and slaughter them or rear them with milk replacers. Milk replacers specially formulated for kids can result in good daily weight gain, although this gain is less than that of kids reared on their mothers. In addition, some farmers are disinclined to use the milk replacer because they consider that this type of rearing involves greater labour cost and results in meat of a lower sensory quality, with a perception that this meat is tougher (Argüello *et al.,* 2005).

Unfortunately, Spanish literature about the influence of production system on carcass characteristics of kids is scarce and even, for some breeds, non-existent, which makes it difficult for farmers to make the managements decisions. Then, the aim of the present work was to characterise some carcass traits of suckling kids of seven Spanish breeds.

Material and methods

The experimental animals were 201 male, single-birth suckling kids from seven Spanish goat breeds, five meat breeds and two dairy breeds. Meat breeds were Blanca Andaluza (BA, n = 19), Blanca Celtibérica (BC, n = 30), Moncaína (MO, n = 32), Negra Serrana-Castiza (NE, n = 30) and Pirenaica (PI, n = 30). For further information about breeds, see http://aplicaciones.mapa.es/arca-webapp/flujos.html?_flowId = anuncio-flow&_flowExecutionKey = e4s1, Sañudo (2011) or http://www.feagas.com/index.php/es/razas/especie-caprina. The slaughter criterion was carcass weight. Two carcass-weight targets were established, 4 kg and 7 kg, which are the more usual weight found in the Spanish market. From these, based on an estimate of dressing percentage, two liveweights were established, 7 kg and 11 kg of live-weigh. Finally, animals were slaughtered at 7.6 kg ± 0.80 kg of live-weight (L, light weight) and at 11.33 kg ± 1.20 kg of liveweight (H, heavy weight). Kids suckled only their mothers' milk and remained permanently indoors, while the dams grazed a few hours day^{-1}, depending on the farm facilities. Kids had no access to concentrates, hay, forages or other supplements. Dairy breeds were Malagueña (MA, n = 30) and Murciano-Granadina (MU, n = 30). In the case of dairy breeds, half of the animals from each breed were reared with dam's milk (natural diet) whereas the other half was reared with a milk replacer (artificial diet) and all of them were slaughtered at light liveweight (4 kg target carcass weight, finally 7.03 kg ± 1.20 kg liveweight), because as explained, in dairy breeds, kids are sold as soon is possible. Some milk samples were taken from different production systems but, unfortunately a problem with analysis make the data invalid and therefore milk's chemical composition is not shown in the present paper.

Because half of the animals from each of the seven breeds used were animals reared on dam's milk and slaughtered at a light liveweight, they could be used to compare breed type (dairy and meat).

When animals reached the target liveweight they were slaughtered using standard commercial procedures and according to the guidelines of Council Directive 86/609/EEC (OJ, 1986) on the protection of animals used for experimental and other scientific purposes. Since the traditional way of presenting carcasses in Spain is with head and kidneys, viscera were removed and weighed and thereafter hot carcasses, including head and kidneys, were weighed. Afterwards, the head was separated and weighed and then, carcasses were hung by the Achilles tendon and chilled for 24 h at 4°C. At 24 hours after slaughter, fatness degree was assessed according to the Regulation (CE) 22/2008 (OJ, 2008). Given that the animals did not have enough subcutaneous fat to measure fat colour, kidney knob fat was removed and used for this purpose. Fat colour was measured with a Minolta CM-2600d spectrophotometer (space CIELAB, D65, 10°, or % UV, SCI), recording luminosity (L*) and the red (a*) and yellow (b*) indexes, from which we calculated saturation (C*) as $C^* = (a^{*2} + b^{*2})^{0,5}$ and the hue (H^0) as $H^0 = \text{arctg}(b^*/a^*)$, expressed in degrees, were calculated. Subsequently, the following linear carcass measurements were taken: carcass length, leg length, rump perimeter and rump width (Ruiz de Huidobro *et al.*, 2005). Finally, to estimate carcass tissue composition, the left shoulder was obtained by a standard procedure (Colomer-Rocher *et al.,* 1987), weighed, vacuum packed, frozen at –20°C, and stored until analysis. Dissection procedure was performed following Colomer-Rocher *et al.* (1987).

Statistical analysis was performed using SPSS 15.0 software. Effects of breed and diet or slaughter weight were studied using two General Linear Model (GLM), one for dairy-breeds and the other for meat-breeds. Means were calculated for every variable in terms of studied effects and differences were considered as significant at $p < 0.05$. To study the relationships between all of the variables a Principal Components Analysis (PCA) without rotation was performed. Finally, to compare all of the breeds a discriminant analysis was carried out including all the carcass traits but using only light liveweight animals fed with dam's milk.

Results

Carcass weights, dressing and measurements

The statistical significance of the effects studied on the variables under consideration is shown in Table 1. Regarding dairy genotypes, it can be seen that breed effect was more important than milk diet effect. Differences between breeds were found for carcass weight, viscera weight, kidney fat weight, carcass and leg length and rump width, whereas milk diet only affected viscera weight. We have found an interaction between effects for fatness score. In the case of meat genotypes, both breed and slaughter weight had a significant effect on the studied variables and there were also many significant interactions between them. We found differences between breeds for all variables except for live-weight, carcass weight and rump perimeter. Slaughter weight affected all of the carcass variables except dressing percentage. We have found interactions for dressing percentage, viscera weight, kidney fat weight, fatness score and rump width, and a tendency towards significance for the carcass length.

Means for carcass weight, dressing percentage and the weights of the head, the viscera and the kidney fat are shown in Table 2, whereas Table 3 shows the means for fatness scores and carcass measurements. Regarding dairy breeds, the breed effect was especially noticeable for kids fed natural milk. MA breed kids pre-

Table 1. Significance (*p* value) of the studied effects (breed and milk diet or slaughter weight) on some carcass weights and traits of kids from seven Spanish breeds

	Dairy breeds				Meat breeds			
	Breed (B)	Milk diet (D)	B*D	SE	Breed (B)	Slaughter weight (W)	B*W	SE
Liveweight	0.101	0.406	0.101	0.16	0.259	0.000	0.476	0.08
Carcass weight	0.023	0.770	0.061	0.11	0.074	0.000	0.553	0.05
Dressing percentage	0.071	0.427	0.435	0.83	0.000	0.650	0.000	0.25
Head weight	0.421	0.896	0.246	5.34	0.003	0.000	0.193	3.55
Viscera weight	0.042	0.022	0.099	10.05	0.000	0.000	0.001	6.88
Kidney fat weight	0.003	0.136	0.424	6.12	0.000	0.000	0.015	4.31
Fatness score	0.186	0.291	0.008	0.19	0.000	0.003	0.000	0.09
Carcass length	0.013	0.329	0.159	0.27	0.000	0.000	0.066	0.17
Leg length	0.014	0.259	0.105	0.11	0.008	0.000	0.218	0.13
Rump perimeter	0.108	0.640	0.409	0.30	0.104	0.000	0.248	0.16
Rump width	0.000	0.710	0.853	0.08	0.000	0.000	0.000	0.06

SE: standard error.

sented higher carcass dimensions (carcass weight, carcass length and rump perimeter and width) than MU. Additionally, MA presented a higher dressing percentage than MU, in spite of the fact that it registered higher viscera and kidney fat weights. When animals were fed with milk replacer, breed effect was less noticeable and differences were only found for kidney fat weight and rump width, higher in MA than in MU, and for leg length, higher in MU than in MA. On the other hand, milk diet was much less important and it only affected kidney fat weight and leg length in MA and viscera weight in MU.

In the case of the meat goat breeds (Table 3), Negra-Serrana (NE) kids had the longest carcasses, the longest legs and the widest rumps in the light-weight group; whereas, in the heavy-weight group, BA had the longest carcasses and the highest rump perimeter and MO had the longest leg and the widest rump. If carcass compactness index is calculated as carcass weight (kg)/carcass length (cm), PI presented the highest values at

Table 2. Slaughter weight, carcass weights and dressing percentages of kids from seven Spanish breeds (means)

Breed[1]	Treatment	Liveweight (kg)	Carcass weight (kg)	Dressing percentage	Head weight (g)	Viscera weight (g)	Kidney fat weight (g)
Dairy							
MA	Natural	7.5 a	5.1 a	68.0 a	440.3	396.5 a	120.8 ax
	Artificial	7.2	4.7	65.3	426.9	413.4	88.4 ay
MU	Natural	6.3 b	4.0 b	63.5 b	419.5	325.6 yb	69.4 b
	Artificial	7.1	4.6	64.8	427.9	403.3 x	50.7 b
Meat							
BA	Light	7.4 y	4.0 by	54.1 b	486.4 ay	274.4 b	35.0 by
	Heavy	12.4 ax	6.6 x	53.4 cd	637.3 x	328.4 c	75.7 cx
BC	Light	7.7 y	4.2 y	54.6 b	477.5 aby	379.6 a	80.9 ay
	Heavy	11.3 abx	6.3 x	56.0 b	612.6 x	588.6 a	140.3 abx
MO	Light	7.4 y	4.3 y	57.4 a	446.9 ay	406.3 ay	86.6 a
	Heavy	10.9 bx	6.1 x	55.6 bc	609.4 x	553.1 ax	78.5 c
NE	Light	8.0 y	4.5 a	56.0 ab	513.3 ay	380.8 ay	81.1 ay
	Heavy	11.2 bx	6.7	59.6 a	627.0 x	445.8 bx	159.2 ax
PI	Light	7.7 y	4.3 y	55.0 ab	479.2 aby	353.3 ay	50.7 by
	Heavy	11.6 abx	6.2 x	53.2 d	616.0 x	550.0 ax	97.3 bcx

[1] MA, Malagueña; MU, Murciano-Granadina; BA, Blanca Andaluza; BC, Blanca Celtibérica; MO, Moncaína; NE, Negra Serrana-Castiza; PI, Pirenaica. a,b: differences between breed within milk diet or slaughter weight; x,y: differences between milk diet or slaughter weight within breed.

Table 3. Carcass measurements of kids from seven Spanish breeds (means)

Breed[1]	Treatment	Fatness score (1-12)	Carcass length (cm)	Leg length (cm)	Rump perimeter (cm)	Rump width (cm)
Dairy						
MA	Natural	4 x	39.9 a	19.8 x	31.7 a	9.5 a
	Artificial	3 y	39.6	19.0 yb	31.6	9.6 a
MU	Natural	3	37.4 b	19.7	30.4 b	8.6 b
	Artificial	3	38.8	20.1 a	30.9	8.6 b
Meat						
BA	Light	1 b	40.7 aby	19.9 aby	29.9 by	8.0 by
	Heavy	1 c	48.0 ax	21.1 abx	37.2 x	11.1 ax
BC	Light	3 ay	39.8 by	19.9 ab	31.4 ay	10.0 ay
	Heavy	4 ax	43.8 bx	20.5 b	36.1 x	11.1 ax
MO	Light	2 a	39.9 by	20.4 ay	32.6 ay	10.0 ay
	Heavy	2 c	43.6 bx	22.2 ax	36.8 x	11.2 ax
NE	Light	1 by	41.6 ay	20.8 a	31.6 ay	10.3 a
	Heavy	3 bx	45.6 bx	22.0 a	36.3 x	10.5 b
PI	Light	3 a	38.2 cy	19.1 by	31.8 ay	9.9 ay
	Heavy	3b	44.0 bx	21.6 abx	36.1 x	11.1 ax

[1] MA, Malagueña; MU, Murciano-Granadina; BA, Blanca Andaluza; BC, Blanca Celtibérica; MO, Moncaína; NE, Negra Serrana-Castiza; PI, Pirenaica. a,b: differences between breed within milk diet or slaughter weight; x,y: differences between milk diet or slaughter weight within breed.

light weight while NE presented the highest values at heavy weight. MO presented higher dressing percentages at light weight, whereas at heavy weight, the highest dressing percentage values were found in PI. BA carcasses were clearly less fattened than the others. Head weight represented 11.4% of the carcass weight in light carcasses (from 8.6-14.3) and 9.9% in heavy carcasses (from 7.3-11.8%) whereas viscera represented 8.6% in light carcasses (from 4.0-13%) and 8.3% in heavy carcasses (from 2.3-12.7%).

As shown by interactions (Table 1), it can be seen in Table 3 that the increase in weight did not affect the carcasses of all the breeds in the same way. In general, carcass length and rump perimeter increased in all breeds with the increase in weight. Leg length, rump perimeter and rump width also increased in BA, MO and PI, whilst in BC leg length did not change and in NE no changes were observed with the increase in weight, either in leg length or rump width, showing a comparatively good morphology at lower weights. However, kidney fat weight was nearly duplicated in all breeds except for MO, in which no weight effect was recorded.

Kidney fat colour

In dairy genotypes (Table 4), breed influenced yellowness (b*) and chroma (C *) of kidney fat and there was a tendency for redness (a*), whereas, milk diet affected L*, a* and hue. No interactions between effects were found. In meat breeds, breed affected all of

Table 4. Significance (*p* value) of the studied effects (breed and milk diet or slaughter weight) on kidney fat colour of kids' carcasses from seven Spanish breeds

	Dairy breeds				Meat breeds			
	Breed (B)	Milk diet (D)	B*D	SE	Breed (B)	Slaughter weight (W)	B*W	SE
L*	0.866	0.039	0.382	0.55	0.000	0.423	0.001	0.34
a*	0.058	0.007	0.714	0.28	0.000	0.480	0.019	0.14
b*	0.003	0.462	0.964	0.32	0.002	0.027	0.020	0.20
C*	0.004	0.214	0.920	0.39	0.000	0.036	0.022	0.22
H^0	0.559	0.001	0.927	0.75	0.000	0.493	0.017	0.54

SE: standard error.

the studied variables whereas slaughter weight only affected b* and C*, and interactions were found for all variables.

Means for fat colour variables are shown in Table 5. Kids from dairy breeds fed with dam's milk had kidney fat with higher L* and H^0, due to lower redness, the effect of the milk diet being more evident in MA than in MU. Fat from MU showed higher values for b* and C* than that from MA, resulting in slightly lower H^0 values. In meat breeds and at light weight, BC presented the highest L* values, whereas BA presented the highest values for redness (a*) and MO presented the lowest yellowness. Subsequently, for light-weight carcasses, fat from BA presented lower H^0 that any other breed, and then this breed has a colour clearly different from the rest of breeds. In addition, MO showed a less intense colour (C*) than the others. In heavy carcasses, NE had the lowest L* values, whereas BA revealed the highest values for a* and b*, resulting in a more intense colour (C*). Therefore we can say that the fat of BA has a colour that is clearly different from the rest at both slaughter weights, since it had lower H^0 and higher C* values.

Carcass tissue composition

Significances of studied effects on carcass composition are shown in Table 6. In dairy breeds, the breed only affected the weight of the shoulder, while milk diet affected muscle and intermuscular fat percentages, there also being an interaction between effects for intermuscular fat percentage. In meat breeds both breed and slaughter weight affected dissection variables, and there were interactions between effects for subcutaneous fat, intermuscular fat and bone percentages.

Means for tissue carcass composition are shown in Table 7. Both dairy breeds presented a higher muscle percentage when animals were fed with milk replacer. In MA this increase was achieved at the expense of fatness, which was lower in the animals that were fed milk replacer, whereas in the MU it was obtained at the expense of the percentage of bone, albeit not significantly (p = 0.051). Differences between dairy breeds were small and they were mainly found in the degree of fatness, which was somewhat higher in MA reared on natural milk than in MU. With regards to meat breeds, the most relevant fact was that BA presented higher muscle percentages at both slaughter weights and the highest values for subcutaneous and intermuscular fat at light weight, whereas BC revealed just the opposite. Increase in weight had a great influence on the tissue carcass composition. In all the breeds, bone percentage decreased when slaughter weight increased, except in NE, where it was not significant.

Table 5. Means for kidney fat colour of kids from seven Spanish breeds

Type	Breed	Treatment	Kidney fat colour				
			L*	a*	b*	C*	H^0
Dairy breeds	MA	Natural	72.9 x	2.8 y	10.8 by	11.2 by	75.7 x
		Artificial	69.5 y	4.2 x	11.3	12.1	70.2 y
	MU	Natural	71.7	3.7	12.9 ax	13.5 ax	75.0 y
		Artificial	70.3	5.6	13.3	14.6	69.1 x
Meat breeds	BA	Light	73.1 c	6.4 a	14.1 a	15.6 a	65.9 c
		Heavy	77.0 a	5.2 a	14.0 a	15.0 a	70.1 bc
	BC	Light	81.5 a	2.4 c	11.9 ab	12.3 bc	80.0 a
		Heavy	80.0 a	2.7 b	11.4 b	11.8 b	77.1 a
	MO	Light	77.0 b	1.9 c	10.0 b	10.2 c	80.1 c
		Heavy	77.9 a	3.9 ab	10.6 b	11.4 b	69.9 a
	NE	Light	75.8 bcx	4.8 b	14.2 a	15.0 a	71.1 b
		Heavy	71.2 by	4.0 ab	10.4 b	11.2 b	68.4 bc
	PI	Light	72.8 c	4.7 b	13.8 a	14.6 ab	71.4 b
		Heavy	77.6 a	3.0 b	11.1 b	11.6 b	75.3 ab

MA, Malagueña; MU, Murciano-Granadina; BA, Blanca Andaluza; BC, Blanca Celtibérica; MO, Moncaína; NE, Negra Serrana-Castiza; PI, Pirenaica. a,b: differences between breed within milk diet or slaughter weight; x,y: differences between milk diet or slaughter weight within breed.

Table 6. Significance (*p* value) of the studied effects (breed and milk diet or slaughter weight) on tissue carcass composition of the shoulder for kids carcasses from seven Spanish breeds

	Dairy breeds				Meat breeds			
	Breed (B)	Milk diet (D)	B*D	SE	Breed (B)	Slaughter weight (W)	B*W	SE
Muscle percentage	0.117	0.001	0.163	0.30	0.000	0.009	0.556	0.25
Subcutaneous fat percentage	0.439	0.178	0.159	0.19	0.000	0.000	0.001	0.08
Intermuscular fat percentage	0.347	0.005	0.049	0.20	0.000	0.003	0.011	0.13
Bone percentage	0.370	0.444	0.300	0.27	0.000	0.000	0.001	0.11
Shoulder weight	0.027	0.945	0.137	10.17	0.023	0.000	0.282	4.62

SE: standard error.

Principal component analysis

Figure 1 shows the principal component analysis performed with some of the carcass variables. Fat colour variables were closely related to each other and C*, H^0 and b* were positively related to each other. L* was positively related to b* and H^0 and negatively related to a*, whereas the correlation between a* and H^0 was negative.

On the right of the PCA picture, it can be seen that all the carcass measurements were related to each other and to carcass weight. Carcass weight was also positively related to dressing percentage and to the degree of fatness of the carcass (fatness score, kidney fat weight, subcutaneous fat percentage and intramuscular fat percentage), but negatively related to bone percentage and not related to muscle percentage.

Discriminant analysis

Figure 2 shows the discriminant analysis using all of the studied variables. Factor 1 explained 52.6% of variability whereas factor 2 accounted for 23.5% of variability. Factor 1 discriminates by b* (negatively) and intramuscular fat percentage and separates

Table 7. Means for tissue carcass composition of the shoulder of kids from seven Spanish breeds (means)

Breed	Treatment	Tissue carcass composition				
		Muscle (%)	Subcutaneous fat (%)	Intermuscular fat (%)	Bones (%)	Shoulder weight (g)
Dairy						
MA	Natural	59.1 y	4.1 ax	10.8 ax	25.0	426.6 a
	Artificial	62.1 x	2.9 y	8.5y	25.1	394.5
MU	Natural	60.8 y	3.1 b	9.5b	25.4	338.1 b
	Artificial	63.0 x	3.1	8.8	23.9	370.8
Meat						
BA	Light	63.1 a	1.3 cy	7.3 c	27.7 ax	372.2 by
	Heavy	65.2 a	2.6 bx	8.3 c	23.3 aby	619.5 ax
BC	Light	59.0 b	3.3 ay	10.2 a	24.6 cx	397.0 aby
	Heavy	60.7 c	4.5 ax	11.6 a	22.3 by	601.4 abx
MO	Light	60.9 aby	3.4 a	9.0 bx	25.1 cx	380.4 aby
	Heavy	63.6 abx	3.1 b	8.1 cy	24.3 ay	546.5 bx
NE	Light	61.8 ab	2.0 by	8.1 bcy	27.2 ab	408.7 ay
	Heavy	61.9 bc	3.6 abx	9.4 bcx	24.4 a	602.4 abx
PI	Light	61.7 ab	2.3 b	8.5 by	26.4 bx	390.9 aby
	Heavy	62.6 b	2.7 b	9.9 bx	24.1 ay	554.6 bx

MA, Malagueña; MU, Murciano-Granadina; BA, Blanca Andaluza; BC, Blanca Celtibérica; MO, Moncaína; NE, Negra Serrana-Castiza; PI, Pirenaica. a,b: differences between breed within milk diet or slaughter weight; x,y: differences between milk diet or slaughter weight within breed.

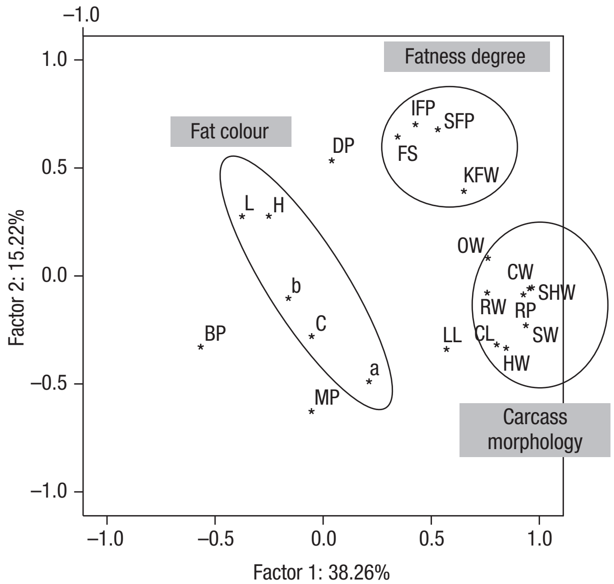

Figure 1. Principal component analysis performed with some carcass variables studied in kids from seven Spanish breeds. a*: redness of fat; b*: yellowness of fat; BP: bone percentage; C*: chroma of fat; CL: carcass length; CW: carcass weight; DP: dressing percentage; FS: fatness score; H: hue of fat; HW: head weight; IFP: intramuscular fat percentage; KFW: kidney fat weight; L*: lightness of fat; LL: leg length; LW: liveweight; MP; muscle percentage; OW: viscera weight; RP: rump perimeter; RW: rump width; SCP; subcutaneous fat percentage; SHW: shoulder weight.

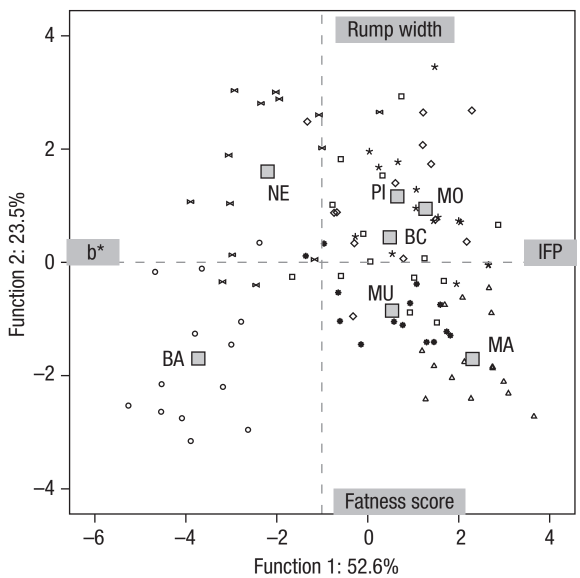

Figure 2. Discriminant analysis performed with some carcass variables studied in kids from seven Spanish breeds. IFP: intramuscular fat percentage. MA: Malagueña; MU: Murciano-Granadina; BA: Blanca Andaluza; BC: Blanca Celtibérica; MO: Moncaína; NE: Negra Serrana-Castiza; PI: Pirenaica.

BA and MA from the rest, BA being the breed with the lowest fatness degree and MA the breed with the highest fatness degree. Factor 2 discriminates breeds by rump width (positively) and by fatness score (negatively). Then dairy breeds were located in the bottom right quarter, indicating that they are breeds with less-pigmented fat, well-fattened carcasses and medium conformations. BA was depicted in the bottom left quarter because of this breed's fat colour and poorer conformation. The rest of the meat breeds are at the top of the picture, indicating a good conformation and medium fatness degree. Of these breeds NE is separated from the rest due to its lower degree of fatness than the rest.

Discussion

Carcass weights, dressing and measurements

Table 2 shows the means of slaughter weight, carcass percentage and head, viscera and kidney weights depending on the considered effects and Table 3 show fatness degree and carcass measurements depending on the considered effects. Our results contradict those found by Argüello *et al.* (2003) in Canary breed kids. Said authors stated that milk diet influences carcass dimensions and shoulder weight, but not the quantity of kidney fat. Concerning slaughter weight, Argüello *et al.* (2003), working with the Canary breed found an effect of slaughter weight (6 kg or 10 kg) on carcass weight and on carcass length, as both increased with the increase in slaughter weight, however they did not find any effect of slaughter weight on fat percentages. In contrast, in the Serrana breed, the most important Portuguese breed of goats, the carcass weight (4, 6 or 8 kg) was found to affect carcass conformation (Teixeira *et al.,* 2011). Current results found for carcass traits were similar to those described by several authors for other breeds (Villanueva, 1998; Jiménez-Badillo, 2007; Santos *et al.*, 2008; Jiménez-Badillo *et al.,* 2009; Zurita-Herrera *et al.*, 2011). Finally, several authors have indicated the positive relationship between carcass weight and dressing percentage or carcass measurements (Colomer-Rocher *et al.*, 1991; Marsico *et al.*, 1993; Marichal *et al.*, 2003; Attah *et al.*, 2004; Jiménez-Badillo, 2007; Santos *et al.*, 2008; Teixeira *et al.,* 2011).

In all breeds, both dairy and meat-specialised, we have found an interaction between effects on fatness scores (Table 1). Fat is late-deposited tissue and in goats, visceral fat is the first to be deposited (Chilliard *et al.*, 1981), its quantity being very variable and depending on many factors, including the physical activity of the animal (Webb *et al.*, 2005).

The interaction found in meat breeds between breed and slaughter weight for dressing percentage, viscera weight, kidney fat weight, fatness score and rump width, seems to indicate that the increase of weight affects the different breeds in different ways and, consequently, different slaughter weight should be recommended to farmers to improve profitability.

Kidney fat colour

The values obtained for fat colour variables (Table 5) agree with the findings of most authors (Villanueva, 1998; Marichal *et al.*, 2003; Jiménez-Badillo, 2007; Santos *et al.*, 2008; Teixeira *et al.,* 2011). The most important observation is that the fat of BA has a colour that is clearly different from the rest at both slaughter weights, presenting higher C* values and lower H^0 values. Priolo *et al.* (2002) concluded that yellowness and chroma seem to be the most appropriate parameters to assess fat colour. Ripoll *et al.* (2012) described that it is possible to distinguish between lambs reared on concentrate or alfalfa by its fat colour, since carotenoids are present in forage but less so in concentrate diets. Similarly, Ryan *et al.* (2007) found that diet could affect to muscle colour, with animals from concentrate diets having higher redness and yellowness of the longissimus muscle. Nonetheless, beyond the interactions and differences found in kidney fat colour, because our animals were very young, fat colour was white in all breeds and it implies that it would be well accepted by consumers (Carrasco *et al.,* 2008).

Tissue carcass composition

Current results in tissue carcass composition (Table 7) are in disagreement with those of Marichal *et al.* (2003) who reported that slaughter weight had no effect on tissue carcass distribution but it agrees with those of Peña *et al.* (2007) or Teixeira *et al.,* (2011), who reported that bone weight decreased and subcutaneous fat and intermuscular fat weights increased when slaughter weight increased. As previously commented, the increase of weight affected the different breeds in different ways and this difference is reflected in the interactions found for tissue carcass composition. Furthermore, it seems evident that the main differences between dairy and meat breed animals are to be found in the amount and distribution of the fat. Subcutaneous fat is developed later than intermuscular fat, which explains why, in young animals, the latter is more important than the former. This pattern coincides with the conclusions offered by several authors in relation to other breeds (Marichal *et al.*, 2003; Jiménez-Badillo, 2007).

The decrease in the percentage of bone with the increase in weight of the carcass has been described by other authors (Todaro *et al.*, 2002; Marichal *et al.*, 2003; Jiménez-Badillo, 2007) and it is explained because the bone is more precocious than other tissues. In MO, the increase in weight was accompanied by an increase in the percentage of muscle, whereas in the rest of the breeds it was accompanied by a general increase in fatness, maybe indicating that MO is a less precocious breed than the rest.

Principal component analysis

Our findings are in agreement with Argüello *et al.* (2005), who described a positive correlation in muscle between L* and H^0 and no relationship between L* and C* or C* and H^0. Also Santos *et al.* (2008) found significant correlations between muscle colour parameters, which were positive for redness and C*, yellowness and H^0 or L* and H^0 and negative for L* and a*, L* and C* or L* and b*. Finally, Ripoll *et al.* (2011), working on the same breeds included in the present work, found a negative correlation between L* and a* and between a* and b* or a* and H^0. The positive correlations between H^0 and C*, b* and H^0, b* and C* and L* with B*, H^0 and C* were always in muscle. Nevertheless, relationships between colour variables differ from muscle to fat, especially in the relationship between a* and b* which is positive in fat whereas in meat is no significant but tended to negative in early stages of ageing and no significant but tended to positive in late stages of ageing (Albertí, 2012). Additionally, it must be taken into account that in the current work, fat colour was measured in kidney fat instead of subcutaneous fat, which is more usual. From the authors' knowledge there are very few papers on the subject of kidney fat colour, and even fewer on small ruminants. Only Ripoll *et al.* (2008) have presented data on the effect of location in which measurements of fat colour were performed in light lambs and demonstrated that L* and a* have higher values and H^0 lower values in kidney fat that in tail fat.

On the right of the PCA picture (Fig. 2), it can be seen that all the carcass measurements were related to each other and to carcass weight, according to Santos *et al.* (2008). Marichal *et al.* (2003) reported that dressing percentage was not related to dissection variables, whereas slaughter weight was negatively correlated with bone percentage. According to Santos *et al.* (2008) fatness measurements were negatively related to both muscle and bone percentage and there was not any relationship between muscle percentage and bone percentage. Indeed, our PCA picture was very similar to that shown by Santos *et al.* (2008).

Discriminant analysis

Santos *et al.* (2008), using several carcass quality parameters, described that the first function was characterised by carcass and leg compactness, carcass weight and subcutaneous fat. The same authors studied the ability of carcass measurements to discriminate between slaughter-weight groups or breed groups of animals and they concluded that there were sufficient differences in slaughter weight to make distinctions between groups, whereas this was not the case with differences between breeds. Similarly, Zurita-Herrera *et al.* (2011) working on the Murciano-Granadina breed reported that canonical discriminant analysis based on carcass traits was able to distinguish between feeding systems (natural rearing, artificial rearing or organic rearing).

From the present results it can be concluded that in dairy breeds, breed affected carcass traits and dissection variables more significantly than milk diet, with the effect particularly large for kids that were fed with natural milk. In meat breeds, slaughter weight and breed affected carcass traits and tissue carcass composition, although the slaughter weight was more important than breed and many significant interactions were found between both effects. The increased of slaughter weight occurred in different way in the different breeds. All carcass traits were closely related to each other and to slaughter weight and slaughter weight was also positively related to dressing percentage and to fatness degree. Discriminant analysis explained 76.1% of variability and separated dairy breeds, with well-fattened, medium-shaped carcasses, from meat breeds, with good conformations and medium fatness degrees. Hence, carcass traits were able to group breeds by diary or meat type.

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