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Effect of sex and carcass weight on carcass traits and meat quality in goat kids of *Cabrito Transmontano*

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Abstract

This work aims to study sex and carcass weight effect on carcass and meat quality characteristics of a protected designation of origin (PDO) product, *cabrito Transmontano*. A total of 60 animals with carcass weight ranging between 4 and 8 kg were used. Carcass conformation, commercial joints, tissues measurements and proportions, carcass pH, meat colour and meat texture were evaluated. Sex had a significant effect on carcass composition and males had higher bone and less intermuscular fat and kidney knob and channel fat proportion than females. Males showed better carcass compactness as a result of a higher hot carcass weight (HCW)/carcass length (K) ratio. Carcass weight significantly affected carcass joint proportion. As the carcass weight increased there was an increase in carcass linear measurements, carcass compactness, chump and breast proportions, fat depots and tissues measurements and a decrease in leg, shoulder, fore ribs and bone proportion. Increasing carcass weight meat became less luminous with more vivid red colour as a result of a progressive brightness reduction and a redness increment. Consequently hue and chroma parameters went through a significant increase and decrease, respectively. A significant effect of carcass weight was found in *longissimus dorsi* muscle measurements, and muscle area increased as well the subcutaneous fat thickness. Carcass weight also had a significant effect on meat texture measured by Warner-Bratzler shear force, which reduced its value as carcass weight increased. The meat quality parameters studied could be a tool to identify and characterize a product with PDO as *cabrito Transmonstano.*

Additional key words: carcass pH; goat meat; meat colour; tissue proportion.

Resumen

Efecto del sexo y peso de la canal en las características de la canal y la calidad de la carne de cabrito de raza Transmontana

El objetivo del trabajo ha sido estudiar el efecto del sexo y del peso de la canal sobre las características de calidad de la canal y de la carne de cabrito Transmontano. Se utilizaron 60 animales con pesos de canal comprendidos entre 4 y 8 kg, evaluándose la conformación y pH de la canal, las piezas comerciales y sus proporciones en tejidos, así como el color y la textura de la carne. El sexo tuvo un efecto significativo en la composición de la canal, observándose en los machos una mayor proporción de hueso y menor de grasa intermuscular pélvica y renal. Aunque el sexo no tuvo un efecto significativo en la proporción de pierna y lomo, los machos presentaron mejor compacidad de la canal debido a una mayor relación peso/longitud de la canal en caliente. El peso de la canal afectó significativamente a la proporción de las piezas, observándose, con el aumento del peso de la canal, valores más elevados de las medidas lineales, de la compacidad y de las proporciones de cadera y pecho, así como en los depósitos de grasa y en la proporción de tejidos. Sin embargo, las proporciones de pierna, espalda, costillas y hueso fueron menores. Al aumentar el peso de la canal, la carne fue menos luminosa y el color rojo más vivo, como consecuencia de una reducción progresiva de la luminosidad y de un aumento del índice de rojo. Consecuentemente, el tono aumentó y el croma disminuyó. Se observó un efecto significativo del peso de la canal en las medidas del músculo *longissimus dorsi,* produciéndose un aumento tanto del área muscular como del espesor de la grasa subcutánea. La textura también se vio significativamente afectada por el peso de la canal, reduciéndose la fuerza al corte (medida con la celda Warner-Blatzer) con el aumento del peso de la canal. Los parámetros de calidad de la carne estudiados podrían ser una herramienta para identificar y caracterizar un producto con denominación de origen protegida como es el cabrito Transmonstano.

Palabras clave adicionales: carne de cabrito; pH de la canal; proporción de tejidos; color de la carne.

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Introduction

Goat meat production in northeast Portugal is based on an extensive system where the local breed Serrana (the most important goat breed in Portugal) is reared to produce two products with PDO (Protected Designation of Origin): the Transmontano goat cheese (*queijo de cabra Transmontano*) and a meat product (*cabrito Transmontano*). The *cabrito* (goat kid) is one of the most important contributions to the goat meat supply in Portugal and owing to old culinary skills it becomes nowadays more and more interesting in the Mediterranean diet lifestyle. Furthermore, as a result of globalization, there has been a sharp rise in the influx of ethnic groups from areas of the world where goat meat plays a significant part in the diet. Consequently, an increase in the consumption of ethnic foods and a broaden interest in their culinary experiences has been observed. Also, goat meat is often consumed in specialty occasions associated with summer holidays, Christmas, Carnival or Easter.

In Portugal as well as in other countries goat meat is sold as whole and half carcasses jointed according to the customer needs. Nowadays, to meet the requirements of modern family lifestyle, most retailers offer several kinds of specified cuts. Reference methods of jointing and dissection are extremely important to provide accurate data of high scientific value (Delfa *et al.*, 1992).

The knowledge of the amount and distribution of muscle, fat and bone in the carcass is interesting to all agents involved in meat production and marketing but it is especially relevant to consumers so long as they pay these tissues at the same price. Carcass tissue composition and distribution depends on several factors such as breed, sex and body weight or carcass weight, and it should be studied according to them as several authors have stated (Colomer-Rocher *et al.*, 1992; Teixeira *et al.*, 1995; Dhanda *et al.*, 1999a,b, 2003; Mourad *et al.*, 2001; Marichal *et al.*, 2003; Santos, 2004). Thus, knowledge of the tissue composition, depending on the major factors that affect it, such as weight and sex, is of paramount importance.

Beyond carcass composition some physical characteristics of meat as pH, colour and texture are also important to assess quality, according to several studies (Babiker *et al.*, 1990; Todaro *et al.*, 2002, 2004; Dhanda *et al.*, 2003; Marichal *et al.*, 2003; Santos, 2004; Argüello *et al.*, 2005).

Assuming the importance of the production of *cabrito Transmontano* the main objective of this work was to study the effects of sex and carcass weight on carcass and meat quality contributing to a best knowledge of this important meat product with a protected origin.

Material and methods

Sixty kids (31 males and 29 females) of the Serrana Transmontana breed were involved in the study distributed according to body and carcass weight as it is shown in Table 1. Goat carcasses were selected by the NASBP (National Association of Serrana Breed Producers) in agreement to the specification-summary of requirements of the *cabrito Transmontano* PDO product (Guide to Community Regulations, 2004). Kids were slaughtered at a certified abattoir recognized by NASBP at different live weights with the purpose of obtaining

Table 1. Animal's distribution according to sex and carcass weight (CW)

	4 kg		6 kg		8 kg	
	♀ (9)	♂ (11)	♀ (10)	♂ (10)	♀ (10)	♂ (10)
BW (kg)	7.2 ± 0.67	7.6 ± 0.71	10.7 ± 0.87	11.3 ± 0.62	14.1 ± 1.21	14.2 ± 1.23
CW (kg)	3.8 ± 0.37	4.0 ± 0.47	5.6 ± 0.64	6.0 ± 0.45	7.9 ± 0.82	7.9 ± 0.62
Dressing %	52.8^{a} ± 3.27	52.9^{a} ± 4.22	52.3^{a} ± 2.00	53.2^{a} ± 2.84	56.0^{b} ± 3.18	56.0^{b} ± 2.25
Significance	Sex					
	Weight					*

BW: body weight. CW: carcass weight. ^{a,b} Different letters in the same row mean significant differences. * $p \leq 0.05$.

Abbreviations used: A (*longissimus* muscle width at the 12th-13th ribs); B (*longissimus* muscle depht at the 12th-13th ribs); C (thickness of subcutaneous fat above B); CW (carcass weight); EZN (Estação Zootécnica Nacional); F (leg length); G (carcass width); HCW (hot carcass weight); IF (intermuscular fat); K (carcass lenght); KKCF (kidney knob channel fat); PDO (protected designation of origin); pH1(pH 1 h after slaughter); pH24 (pH 24 h after slaughter); SF (subcutaneous fat).

carcass weights in the range established by the PDO, *i.e.,* between 4 and 9 kg, three carcass weight groups have been considered for each sex. At the abattoir the hot carcass weight (HCW) and pH were recorded. Carcasses were chilled for 24 h and then transported to the Laboratory of Carcass and Meat Technology and Quality in the Agricultural School of Bragança. Carcass pH was determined by performing two repetitions, one hour (pH1) and 24 h (pH24) after slaughter in the 12th-13th ribs, using a portable pH meter Crison 507 equipped with a 52-32 penetration electrode. Then, carcasses were split longitudinally and some carcass measurements (Pálsson, 1939; Wood and MacFie, 1980) were taken: leg (F) and carcass (K) length, carcass width (G), and *longissimus dorsi* muscle measurements at the 12th-13th ribs: width (A), depth (B), rib eye area and thickness of subcutaneous fat above B (C). The following indexes were calculated: G/F or leg compactness and HCW/K or carcass compactness. The left side of split carcass was divided into eight commercial joints (leg, chump, loin, ribs, fore ribs, shoulder, breast and neck) according to the jointing procedure of the Zootechnical National Station Cut (Estação Zootécnica Nacional-EZN Cut) proposed by Calheiros and Neves (1968) and described by Teixeira (1984). Kidney knob and channel fat (KKCF) was removed and weighed separately. At this time, meat colour was assessed by L*a*b* system using a colorimeter (Minolta CR 300), with two repetitions in the *longissimus* muscle at the 12th-13th thoracic vertebrae. Hue and chroma parameters were calculated. All joints were vacuum packed and deep-frozen at –25°C. After defreezing, each joint was then dissected into muscle, subcutaneous fat (SF), intermuscular fat (IF), bone, and remainder (major blood vessels, ligaments, tendons and thick connective tissue sheets associated with some muscles) in a dissection room under controlled environment. *Longissimus* muscle was removed (at the 12th-13th left thoracic semi-vertebrae) and then placed inside a bag in a water bath heated to 70°C. After cooling the muscle under cool running water for 30 min was cut (cut line parallel to muscle fibres direction) in pieces of about 2 cm long and 1 cm^2 of section, and the maximum shear force was measured (8 repetitions for sample) in kgf with an Instron press equipped with a Warner-Bratzler cell (WBSF), in accordance with the methodology described by Beltrán and Roncalés (2005).

Data were analyzed using the mixed models procedure (Proc Mixed) of SAS statistical package (SAS, 1998) to assess the influence of sex and weight on carcass and meat quality characteristics. Sex and carcass weight and their interaction were fitted as fixed effects. However, when no interaction was observed, interaction effect was removed from the model in the final analysis. A pairwise Tukey test was used to analyze the significance of differences found between the adjusted means of sex and carcass weight.

Correlation coefficients among the different meat quality characteristics were computed by means of Pearson correlation coefficient (SAS, 1998).

Results and discussion

Body weight, carcass weight, and dressing percentage of the animals in study are presented in Table 1. Dressing percentage is not influenced by carcass weight increase in the lightest animals. However, 8 kg animals presented a significantly higher dressing percentage. Asenjo *et al.* (2005) reported the influence of weight on dressing percentage indicating that this variable can have a different effect depending on the breed. In this particular breed, heavier animals may present higher body and carcass fat quantity, as this is a local breed with similar raising system as Churra Galega Bragançana sheep breed, with higher internal body fat contents than the improved breeds, producing a higher dressing percentage as in Teixeira *et al.* (1996) have pointed out.

Effects of sex and carcass weight on carcass conformation are shown in Table 2. Carcass compactness assessed by the HCW/K index was affected by sex and carcass weight as males were more compact ($p < 0.05$), and as the more carcass weight increased, the more compactness increased. These results confirm the evidence found in dairy goats by Koyuncu *et al.* (2007) that as carcasses become heavier compactness index increased. Carcass conformation measurements are also in agreement with the results of the studies made on West African dwarf goats by Mourad *et al.* (2001), and by Santos *et al.* (2008) in *Bravia* goat kids.

Least squares means for sex and carcass weight effect on carcass commercial joints proportion are presented in Table 3. Joint percentages were calculated taking into account KKCF as a carcass component, as it is usual in small ruminants in the Mediterranean area. Joint percentages are in agreement with the results found by Santos *et al.* (2008) in goat kid carcasses of the Protected Geographical Designation (PGI) *Cabrito de Barroso*. Females had a higher ($p < 0.05$) proportion

Table 2. Sex and carcass weight effect in carcass dimensions and conformation indices

		F (mm)	G (mm)	K (mm)	G/F	HCW/K
Sex	♀	255.2 ± 1.92	144.3 ± 1.34	404.0 ± 4.56	0.57 ± 0.005	0.14^{b} ± 0.002
	♂	258.3 ± 1.86	143.7 ± 1.30	407.9 ± 4.41	0.56 ± 0.004	0.15^{a} ± 0.002
Carcass weight	4 kg	232.7^{c} ± 2.33	130.8^{c} ± 1.62	365.8^{c} ± 5.52	0.56 ± 0.006	0.11^{c} ± 0.002
	6 kg	262.0^{b} ± 2.31	145.5^{b} ± 1.62	407.9^{b} ± 5.49	0.56 ± 0.006	0.14^{b} ± 0.002
	8 kg	275.6^{a} ± 2.31	155.8^{a} ± 1.62	444.2^{a} ± 5.49	0.57 ± 0.006	0.17^{a} ± 0.002
Significance	Sex					*
	Weight	***	***	***		***

F: leg length. G: carcass width. K: carcass length. HCW: hot carcass weight. ^{a,b,c} Different letters in the same column mean significant differences. * $p \leq 0.05$. *** $p \leq 0.001$.

of chump, breast and KKCF, while males had a higher ($p < 0.05$) proportion of ribs and shoulder. The increase in carcass weight resulted in a rise ($p < 0.05$) of chump and breast weight. Loin proportion slightly became greater ($p < 0.05$) when carcass weight increased from 4 to 6 kg, but decreased ($p < 0.05$) when carcass weight had risen from 6 to 8 kg. Moreover, KKCF percentage initially decreased ($p < 0.05$) and then increased ($p < 0.05$) as the weight augmented. According to the studies by Colomer-Rocher *et al.* (1992) and Teixeira *et al.* (1995), a significant reduction in leg and shoulder proportion, as it has been confirmed in this work, should be expected. There was also a decrease ($p < 0.05$) in fore ribs proportion and at a similar carcass weight, weights of carcass joints, expressed as a percentage of side carcass weight, agree with those reported by Colomer-Rocher *et al.* (1992) in Saanen goats, by Hadjipanayotou and Koumas (1994) in Damascus kids, by Marichal *et al.* (2003) in Canary goats, by Koyucun *et al.* (2007) in Turkish air kids and by Santos *et al.* (2008) in Portuguese *Bravia* goats.

Regarding tissues percentages (Table 4), females had a higher ($p < 0.05$) fat proportion (IF and KKCF), and a lower ($p < 0.05$) bone proportion than males, in agreement with Asenjo *et al.* (2005). Globally, a significant increase in fat depots and a significant reduction in bone proportion with the augment of carcass weight were observed in agreement with the results found by Johnson *et al.* (1995) in young goats, and, taking into account the allometric coefficients by Teixeira *et al.* (1995) in Serrana kids from Montesinho Natural Park (NE of Portugal), indicating the early development of bone and later development of fat. Nevertheless, working with another Portuguese goat breed, Santos *et al.* (2008) did not find any sex effect on carcass composition at such a low slaughter age or weight.

Table 5 shows no significant differences ($p > 0.05$) between males and females in A, B and C in *longissimus* muscle measurements, in agreement with results observed in muscle proportion. Although muscle proportion had not significantly increased as carcass weight did, all *longissimus* muscle A, B and area measurements

Table 3. Sex and carcass weight effect in carcass commercial joints proportion

Item, %	Sex		Carcass weight			Significance	
	♀	♂	4 kg	6 kg	8 kg	Sex	Weight
Leg	24.0 ± 0.35	24.7 ± 0.34	25.4^{a} ± 0.42	23.9^{b} ± 0.42	23.8^{b} ± 0.42		*
Chump	7.8^{a} ± 0.10	7.5^{b} ± 0.10	7.4^{b} ± 0.12	7.5^{b} ± 0.12	8.1^{a} ± 0.12	*	***
Loin	9.6 ± 0.24	9.7 ± 0.23	9.7^{ab} ± 0.29	10.2^{a} ± 0.29	9.0^{b} ± 0.29		*
Ribs	6.2^{b} ± 0.14	6.7^{a} ± 0.13	6.1 ± 0.16	6.5 ± 0.16	6.7 ± 0.16	**	
Fore ribs	5.2 ± 0.14	5.1 ± 0.13	5.3^{a} ± 0.17	5.4^{a} ± 0.17	5.0^{b} ± 0.17		**
Shoulder	19.9^{b} ± 0.19	20.6^{a} ± 0.19	20.9^{a} ± 0.23	20.0^{b} ± 0.23	19.8^{b} ± 0.23	**	**
Breast	11.8^{a} ± 0.22	11.0^{b} ± 0.21	10.3^{b} ± 0.27	11.8^{a} ± 0.26	12.2^{a} ± 0.26	*	***
Neck	11.8 ± 0.20	11.6 ± 0.19	11.8 ± 0.24	11.8 ± 0.24	11.5 ± 0.24		
KKCF	3.8^{a} ± 0.26	3.0^{b} ± 0.25	3.1^{ab} ± 0.31	2.9^{b} ± 0.31	4.1^{a} ± 0.31	*	*

KKCF: kidney, knob and channel fat. ^{a,b,c} Different letters in the same row mean significant differences. * $p \leq 0.05$. ** $p \leq 0.01$. *** $p \leq 0.001$.

Table 4. Sex and carcass weight effect in carcass tissues proportion

		Muscle	SF	IF	Bone	Remainder	KKCF
Sex	♀	58.4 ± 0.52	4.8 ± 0.19	9.2^{a} ± 0.26	20.2^{b} ± 0.24	3.7 ± 0.14	3.8^{a} ± 0.26
	♂	58.9 ± 0.50	4.5 ± 0.19	8.0^{b} ± 0.25	21.7^{a} ± 0.23	3.9 ± 0.13	3.0^{b} ± 0.25
Carcass weight	4 kg	58.1 ± 0.63	4.1^{b} ± 0.23	7.8^{b} ± 0.31	23.2^{a} ± 0.28	3.9 ± 0.17	3.1^{ab} ± 0.31
	6 kg	59.7 ± 0.63	4.4^{b} ± 0.23	8.5^{ab} ± 0.31	20.7^{b} ± 0.28	3.8 ± 0.17	2.9^{b} ± 0.31
	8 kg	58.2 ± 0.63	5.5^{a} ± 0.23	9.5^{a} ± 0.31	18.9^{c} ± 0.28	3.7 ± 0.17	4.1^{a} ± 0.31
Significance	Sex			**	***		*
	Weight		***	**	***		*

SF: subcutaneous fat. IF: intermuscular fat. KKCF: kidney, knob and channel fat. ^{a,b,c} Different letters in the same column mean significant differences. * $p \leq 0.05$. ** $p \leq 0.01$. *** $p \leq 0.001$.

became higher and subcutaneous fat cover, assessed by C measurement, increased.

Table 6 shows sex and carcass weight effect in pH at one and 24 h after animals' slaughter, on meat colour characteristics and in WBSF. Sex had a little effect ($p < 0.05$) on pH1, but did not affect ($p > 0.05$) pH24, in agreement with Santos *et al.* (2008), who did not find any differences between sexes in pH24. There was also no effect ($p > 0.05$) of carcass weight on pH1, which is in accordance with the results by Marichal *et al.* (2003) and by Argüello *et al.* (2005) that did not find differences in pH1 after slaughter in kids of 6 and 10 kg and of 6, 10 and 25 kg carcass weight, respectively. Although pH value found can be considered a normal one, carcass weight had a significant but small effect in reducing pH24, in agreement with Dhanda *et al.* (2003), who showed that this variable was lower in heavier animals, and with Marichal *et al.* (2003), who found a significant decrease in pH24 in the *longissimus* muscle in animals between 6 and 25 kg liveweight.

As carcass weight increased the linear measurements became greater as well as carcass compactness, chump, breast, fat depots and tissues measurements, meanwhile the leg, shoulder, fore ribs and bone proportions diminished. The increase in carcass weight made meat become less bright and with a more vivid red colour, as a result of a progressive decrease in L* (brightness) from 46.0 to 43.9, and an increase in redness (a*) from 9.5 to 13.8, and consequently hue and chroma underwent significant increase and decrease, respectively.

Muscle colour is an important trait to assess carcass and meat quality and was significantly ($p < 0.001$) affected by carcass weight so long as brightness (L*) decreased as carcass weight increased, in accordance with Marichal *et al.* (2003) and Argüello *et al.* (2005). Carcass weight also affected red index (a*) but did not affect ($p > 0.05$) yellow index (b*). In opposite to the results of this work, Dhanda *et al.* (2003) found that capretto and chevon carcasses with the highest weight were not significantly different from the lightest in L* and a*, but they showed a significantly higher b*. Moreover, males were not significantly different from females in respect to these variables, in close agreement to the results obtained by Santos (2004) and Todaro *et al.* (2004).

Muscle colour data also indicated a significant effect of carcass weight on meat hue and chroma in accordance with the findings by Marichal *et al.* (2003). There was a decrease in the hue and an increase in the chroma

Table 5. Sex and carcass weight effect on *longissimus* muscle width (A), depth (B) and rib eye area and subcutaneous fat depth above B, at the 12^{th}-13^{th} ribs (C)

		A (mm)	B (mm)	Area (mm^2)	C (mm)
Sex	♀	37.5 ± 0.69	17.1 ± 0.36	57.3 ± 1.90	1.08 ± 0.094
	♂	39.2 ± 0.67	17.0 ± 0.35	61.1 ± 1.84	1.09 ± 0.090
Carcass weight	4 kg	34.1^{c} ± 0.83	14.3^{c} ± 0.44	43.5^{a} ± 2.30	0.88^{b} ± 0.131
	6 kg	38.8^{b} ± 0.83	17.2^{b} ± 0.43	58.4^{b} ± 2.29	0.91^{b} ± 0.108
	8 kg	42.1^{a} ± 0.83	19.8^{a} ± 0.43	75.5^{c} ± 2.29	1.47^{a} ± 0.096
Significance	Sex				
	Weight	***	***	***	***

^{a,b,c} Different letters in the same column mean significant differences. * $p \leq 0.05$. ** $p \leq 0.01$. *** $p \leq 0.001$.

Table 6. Sex and carcass weight effect on meat pH at 1 hour and 24 hours after slaughter, on meat colour characteristics and on meat Warner-Bratzler shear force (WBSF)

	Sex		Carcass weight			Significance	
	♀	♂	4 kg	6 kg	8 kg	Sex	Weight
pH1	$6.3^{b} \pm 0.05$	$6.5^{a} \pm 0.04$	6.4 ± 0.05	6.4 ± 0.05	6.4 ± 0.05	*	
pH24	5.9 ± 0.03	5.8 ± 0.03	$5.9^{a} \pm 0.03$	$5.8^{ab} \pm 0.03$	$5.8^{b} \pm 0.03$		*
L*	45.6 ± 0.64	47.1 ± 0.61	$49.0^{a} \pm 0.77$	$46.4^{b} \pm 0.76$	$43.6^{c} \pm 0.76$		***
a*	12.2 ± 0.52	11.4 ± 0.50	$9.5^{b} \pm 0.63$	$12.1^{a} \pm 0.62$	$13.8^{a} \pm 0.62$		***
b*	9.7 ± 0.20	9.7 ± 0.20	9.6 ± 0.24	10.0 ± 0.24	9.3 ± 0.24		
Hue	39.4 ± 1.30	41.6 ± 1.25	$46.4^{a} \pm 1.57$	$40.0^{b} \pm 1.56$	$35.1^{b} \pm 1.56$		***
Chroma	15.7 ± 0.45	15.1 ± 0.44	$13.5^{b} \pm 0.55$	$15.8^{a} \pm 0.54$	$16.8^{a} \pm 0.54$		***
WBSF	6.7 ± 0.31	7.2 ± 0.30	$7.8^{a} \pm 0.37$	$7.1^{ab} \pm 0.37$	$5.9^{b} \pm 0.37$		**

^{a,b,c} Different letters in the same row mean significant differences. * $p \leq 0.05$. ** $p \leq 0.01$. *** $p \leq 0.001$.

value that suggests that carcass weight increase caused a decrease in the stimulus that allows understand a given colour and an increase in the stimulus that allows perceiving the colour in a correct way. Additionally, Dhanda *et al.* (2003) observed an increase in chroma, but also in hue, as slaughter weight increased. In short, we can say that kids in study presented, as carcass weight increased, a less bright and a less noticeable hue meat. However, meat presented a redder and more vivid colour. Independently of breed, of carcass weight or of production system, meat colour should ever be measured in order to assess meat quality.

There was a significant effect of carcass weight in WBSF maximum load. An increase in carcass weight drove to a reduction in cutting forces. These results should not be expected taking into account the results of several studies (Dhanda *et al.*, 1999c, 2003; Marichal *et al.*, 2003; Argüello *et al.*, 2005), that stated that the cutting force increases as carcass weight does. This could be due to the different methodologies used in those studies, particularly different breeds, body weight, and muscles used. In the present work a progressive increase in fat quantity was found as carcass weight increased, that could avoid a potential muscle cold shortening effect and make the meat tender and softer, as reported by Savell *et al.* (2005). In fact, WBSF was reduced from 7.8 to 7.1 and to 5.9 when carcass weight increased from 4 to 6 and to 8 kg. No sex differences were found in shear force as it has been noted by Santos (2004). However, Johnson *et al.* (1995) working with five Florida native breeds with 10 kg carcass weight found that females had lower shear force compared with intact and castrated males. Although differences were not significant, it was found a trend in females to have lower shear force than males.

Relations among meat physical characteristics are showed in Table 7. Globally, results are in agreement with Safari *et al.* (2001) who found very low correlationships ($r = 0.05$) between pH and WBSF in different sheep genotypes. As expected, pH was highly correlated with meat colour parameters. Also, high correlations were found between L* and a* values ($r = –0.73$), suggesting that the brighter the meat, the lesser the red colour; between L* and hue ($r = 0.89$), indicating that

Table 7. Pearson correlation coefficients (r) among all meat physical and colour characteristics

	pH1	pH24	L*	a*	b*	Hue	Chroma	WBSF
pH1	1							
pH24	0.081	1						
L*	0.009	–0.064	1					
a*	–0.223	–0.300*	–0.728***	1				
b*	–0.206	–0.453***	0.329*	0.269*	1			
Hue	0.172	0.143	0.888***	–0.908***	0.116	1		
Chroma	–0.249	–0.373**	–0.568***	0.969***	0.490***	–0.779***	1	
WBSF	0.318*	0.135	0.197	–0.327*	–0.188	0.271*	–0.339**	1

WBSF: Warner-Bratzler shear force. * $p \leq 0.05$. ** $p \leq 0.01$. *** $p \leq 0.001$.

hue is better perceived in brighter meat; between hue and a* ($r = –0.91$), which showed that the more red the meat, the worse the hue perception; between a* and chroma ($r = 0.97$) which would mean that redder meat has more colour quantity and between hue and chroma ($r = –0.78$), suggesting that in colourful meat the hue is perceived worse.

Conclusion

Taking into account the results obtained on *Transmontana* goats' meat quality, it can be concluded that, at weight ranges stablished by PDO rules, males presented higher carcass compactness, ribs, shoulder and bone proportions and smaller chump, breast, IF and KKCF proportions than females. But no relevant differences between sexes in physical meat characteristics were observed. In turn carcass weight affected carcass dimensions, carcass joint proportion, fat depots and tissue measurements. The heaviest carcasses were more compact and fatter. However, the lightest carcasses presented higher primal cuts as leg, fore ribs and shoulder. Heavier carcasses provided less tough meat when evaluated by the WBSF. With carcass weight increase meat becomes less bright and less red, showing a small decrease in pH at 24 hours after slaughter.

Generally, meat physicochemical characteristics were not correlated to each other, since only correlation coefficients among colour parameters and pH were high and significant.

Results globally confirm that color and pH are two important factors that influence the kid meat and affect the perception of the quality of the product. The meat quality parameters studied could be a tool to identify and characterize a product with PDO as *cabrito Transmonstano.*

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