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Carcass composition and meat quality of equally mature kids and lambs[1]

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ABSTRACT: Carcass composition and meat quality attributes of 55 suckling kids (27 males and 28 females) and 57 suckling lambs (28 males and 29 females) of Portuguese native breeds were investigated. These suckling kid and lamb meats are European meat quality labels produced according to "Cabrito de Barroso–PGI" and "Borrego Terrincho–PDO" specifications, respectively. Female kids were slaughtered at 9.1 ± 0.36 kg of BW, and male kids were slaughtered at 10.4 ± 0.37 kg of BW, corresponding to 20.1 and 17.7% of maturity, respectively. Female lambs were slaughtered at 8.6 ± 0.53 kg of BW, and male lambs were slaughtered at 9.9 ± 0.23 kg of BW, corresponding to 19.9 and 17.1% of maturity, respectively. At 24 h postmortem, various yield and quality measurements were collected. The left sides of the carcasses were dissected into muscle, subcutaneous fat, intermuscular fat, and bone. Final pH, instrumental color (L*, a*, b*), carcass measurements, and kidney knob and pelvic fat were also determined. Samples of LM were taken from the lumbar and thoracic cuts for intramuscular and meat quality determinations. At 72 h postmortem, a sample of LM was used for cooking losses and Warner-Bratzler shear force determination. Suckling lambs had greater dressing proportion than suckling kids ($P < 0.01$). Carcass fatness was not affected by species ($P > 0.05$), but females had greater kidney knob and pelvic fat proportion than males ($P < 0.01$). Lambs had greater proportions of the highly valued leg cut and lower proportions of shoulder, anterior rib, and neck cuts than kids. Dissection results indicated that kid carcasses had greater muscle content and lower dissected fat and bone than lambs. Kids had greater ($P < 0.001$) muscle ultimate pH value than lambs (5.8 ± 0.02 vs. 5.6 ± 0.02). Males had greater ($P < 0.05$) muscle ultimate pH value than females (5.7 ± 0.02 vs. 5.6 ± 0.02). The kid meat was significantly lighter ($P < 0.05$) and less yellow ($P < 0.001$) than the lamb meat. Kids presented less cooking losses ($P < 0.001$) than lambs, and shear force value was significantly greater ($P < 0.01$) in lamb meat. The kid meat had significantly more moisture ($P < 0.001$) and less intramuscular fat content ($P < 0.001$) than lambs. At this maturity stage, there were significant differences on both carcass and meat quality attributes of suckling kids and lambs, possibly due to inherent differences between species.

Key words: carcass composition, meat quality, suckling lamb, suckling kid

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INTRODUCTION

One of the most widely used systems in sheep and goat farming in Mediterranean countries involves the slaughter of lambs and kids of dairy breeds at 4 to 6 wk of age with a low BW ranging approximately between 10 and 11 kg (Sañudo et al., 1998; Marichal et al., 2003). Fresh suckling kid and lamb meat are regarded as products with high edible value (Santos-Silva et al., 2002). Effects of sex and slaughter weight on carcass composition and meat quality of suckling kids (Argüello et al., 2005; Santos et al., 2007a,c) and lambs (Beriain et al., 2000; Santos et al., 2007b) of some breeds have been reported before. However, data on the relative quality of carcasses of suckling kids compared with that of suckling lambs are very limited. Several studies have been conducted to compare carcass composition and meat quality of sheep and goats at the same slaughter weight or under similar feeding management (Tshabalala et al., 2003; Sen et al., 2004; Lee et al., 2007). Age or live BW at slaughter, or both, are the most usual comparing basis on carcass composition and meat quality studies. If the species or breeds being compared at the same BW or age have different mature BW, then the results obtained can be considered as a confounded combination of genetic differences in

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Table 1. Means (±SE) of slaughter live BW (SLW), maturity, HCW, and cold carcass weight (CCW) of male and female kids and lambs

Species	Sex	n	SLW, kg	Maturity, %	HCW,[1] kg	CCW, kg
Kids	Female	27	9.1 ± 0.36	20.1 ± 0.81	5.9 ± 0.23	4.6 ± 0.21
	Male	28	10.4 ± 0.37	17.7 ± 0.63	6.4 ± 0.24	5.0 ± 0.21
Lambs	Female	28	8.6 ± 0.53	19.1 ± 0.61	5.4 ± 0.31	4.2 ± 0.26
	Male	29	9.9 ± 0.23	17.1 ± 0.40	5.9 ± 0.27	4.8 ± 0.23

[1]Includes head, liver, lungs, heart, and kidneys.

adult BW and differences in degree of maturity (Mahgoub and Lodge, 1998). In this study, suckling kids and lambs were slaughtered within BW limits (8 to 11 kg of live BW) dictated by origin-labeled products, which they belong, corresponding to approximately 19% of maturity. There are inherent differences between the 2 species. Goat meat tends to be darker red (Sheridan et al., 2003) and less tender than sheep (Webb et al., 2005) and is characterized by a low intramuscular and subcutaneous fat content (Babiker et al., 1990; Mahgoub and Lodge, 1998) at comparable ages and sexes. Thus, the aim of this study was to compare the carcass composition and meat quality attributes of equally mature kids and lambs raised under similar environmental conditions.

MATERIALS AND METHODS

Animals and Management

This experiment was conducted in accordance with principles and guidelines outlined in Guidelines for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1999).

The experimental group consisted of 55 suckling kids (27 males and 28 females) and 57 suckling lambs (28 males and 29 females) of Portuguese native breeds produced according to "Cabrito de Barroso–PGI" (Santos et al., 2007a) and "Borrego Terrincho–PDO" (Santos et al., 2007b) specifications, respectively. "Cabrito de Barroso–PGI" and "Borrego Terrincho–PDO" are European meat quality labels (Commission Regulation EEC No. 1107/96) that have some specificity attributed to a particular region and to a traditional production method. According to protected geographical indication (PGI) specifications, carcasses of "Cabrito de Barroso–PGI" must weigh from 4 to 6 kg, be obtained from kids up to 3 mo of age, be raised on pasture with their mothers in the Barroso region (north of Portugal), and belong to the native Serrana and Bravia goat breeds or their crossbreeds (SPOC, 2008). According to protected denomination of origin specifications, carcasses of "Borrego terrincho–PDO" belong to the native Churra da Terra Quente breed, mainly used for milk yield and milk-fed lambs, which are slaughtered at 4 to 6 wk of age, to obtain carcasses of approximately 4 to 8 kg (SPOC, 2008).

The study area is located in the northeast of Portugal at 400- to 700-m altitude above sea level. The average annual temperature is 11.9°C, with an average minimum temperature of 0.9°C (January) and a maximum average temperature of 21°C (July). The relative humidity varies between 60 and 84% with a mean annual rainfall of 741 mm, distributed with peaks in the winter and autumn and dry summers. In general, soils are low in organic matter and of acid reaction with a low cation exchange capacity and available phosphate and high or medium available K_2O (Martins and Coutinho, 1988).

Sheep and goat flocks raised in the northeast of Portugal follow a similar production system. Briefly, ewes and goats meet their nutritional needs mainly through grazing of natural pastures interspersed with areas of shrubby vegetation. The main plant species present in the pastures are *Lolium perenne*, *Holcus lanatus*, and *Bromus* sp. Pastures are used all year by groups of about 100 ewes or goats at a low stocking rate (1 livestock unit per hectare, according to the equivalences established by the Common Agricultural Policy between cattle, sheep, and goats: 1 cow = 7 ewes = 7 goats). The lambing season occurs mainly during September to December. In this production system, kids and lambs are penned at the farm during the first 2 wk. After this period, kids and lambs are naturally suckled and left with their mothers at pasture areas.

Kids and lambs were weighed weekly until they reached a range of live BW between 8 and 11 kg, corresponding to approximately 19% of maturity (Table 1). Live BW at slaughter (Table 1) was recorded after 14 h of fasting with free access to water. Kids and lambs were slaughtered using standard commercial procedures.

The degree of maturity was defined as: (slaughter weight/adult BW) × 100 (Fitzhugh and Taylor, 1971). The adult live BW for each species and breed was estimated as the average BW of adult male (58.2 ± 0.46 kg, n = 314) and female (45.1 ± 0.37 kg, n = 3201) sheep and male (57.7 ± 0.35 kg, n = 224) and female (44.6 ± 0.37 kg, n = 2206) goats belonging to the same flock and herds, respectively.

Carcass Measurements, Cutting, and Dissection

Carcass dressing was performed after the methods of Fisher and de Boer (1994). Carcasses were refrigerated for 24 h at 4°C. Hot and cold carcass weights (HCW and CCW, respectively) were recorded. The carcasses

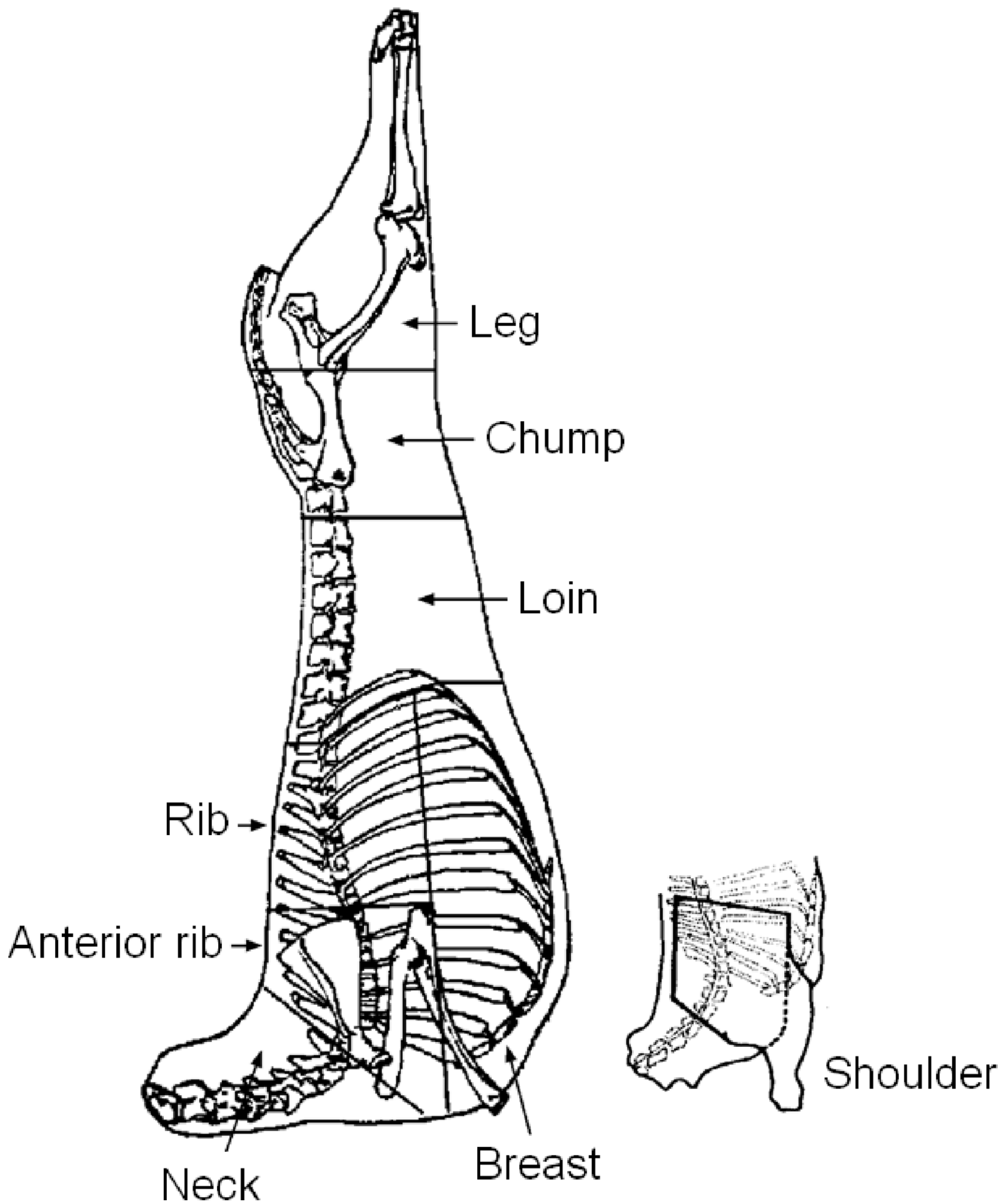

Figure 1. Representation of the carcass cuts (Calheiros and Neves, 1968).

were split along the vertebral column, and the kidney knob and pelvic fat (**KKPF**) was weighed. Several carcass measurements, as outlined by Fisher and de Boer (1994), were taken from all carcasses: leg length (from the symphysis pubis to the tarsal-metatarsal joint), internal carcass length (L; length from anterior edge of the symphysis pubis to the anterior edge of the first rib), as well as chest circumference, anterior buttock circumference, and posterior buttock circumference. Carcass compactness, used as a conformation indicator, was determined as the ratio between CCW and internal carcass length measure (CCW/L, $kg \cdot m^{-1}$). The left side was fabricated into commercial cuts, as outlined by Calheiros and Neves (1968; Figure 1). Greater-priced cuts were leg, chump, and loin. After weighing, each cut was separated into dissectible muscle, bone, fat (subcutaneous and intermuscular fat depots were registered separately), and the remainder (major blood vessels, ligaments, tendons, and thick connective tissue sheets associated with some muscles) in a dissection room under controlled environment with temperature maintained below 15°C.

Muscle Sampling

The LM samples were taken at 24 h postmortem between the 6th thoracic vertebra and 5th lumbar vertebrae from the right half of each carcass, whereas the left half was fabricated into commercial cuts. One part of the LM (between the 12th thoracic vertebra and

5th lumbar vertebrae) was packaged in vacuum bags (Combivac, Felzmann, Linz, Austria) using a packaging machine (Minipack–Torre SpA, MVS–35, Dalmine, Italy) and aged at 4°C for 72 h for cooking losses and Warner-Bratzler shear force determinations. The remaining portion, approximately 100 g, was frozen and stored at −20°C until chemical analysis (<1 mo).

Meat Quality Measurements

The pH was evaluated at 1 and 24 h (**pH_{24}**) postmortem in the LM between 1st and 2nd lumbar vertebrae, using a pH meter equipped with a penetrating electrode and thermometer (Hanna Instruments, HI–9025, Woonsocket, RI). Meat color was assessed by L*, a*, and b* system (CIE, 1986) using a Minolta CR-10 colorimeter (Osaka, Japan). The color was measured on the muscle surface at the same site as the pH, at 60 min after cutting. Cooking loss was evaluated in refrigerated meat samples of similar geometry, individually placed inside polyethylene bags in a water bath at 75°C. Samples were heated to an internal temperature of 70°C, monitored with thermocouples introduced in the core, and cooled for 15 min under running tap water. They were taken from the bags, dried with filter paper, and weighed. Cooking loss was expressed as the percentage of loss related to the initial weight. After measurement of cooking loss, samples were stored in a refrigerator and used for objective tenderness determinations (after equilibration at room temperature). The Warner-Bratzler shear force was evaluated in subsamples (at least 3), prepared manually, of 1 cm^2 cross section and 3 to 4 cm in length, with the fibers perpendicular to the direction of the blade attached to a Stevens QTS 25 (Essex, UK) apparatus. Intramuscular fat was determined with 20.0 g (in duplicate) of minced meat via the Soxhlet extraction method using petroleum ether as the solvent and was determined gravimetrically after evaporating the solvent (AOAC, 2000).

Statistical Analysis

The data were analyzed using the GLM procedure (SAS Inst. Inc., Cary, NC) to determine the influence of species, sex, and their interaction on carcass and meat quality characteristics. Least squares means were computed and tested for differences using Bonferroni's test.

RESULTS AND DISCUSSION

A data summary, including the number of carcasses and the means of slaughter live BW, degree of maturity, and carcass weights in each group, is presented in Table 1.

Carcass Traits and Composition

Suckling lambs had greater dressing proportion (based on CCW) than suckling kids (Table 2). Similar results were reported by Mahgoub and Lodge (1998), Riley et al. (1989), and Tshabalala et al. (2003) on comparative studies of these 2 species at greater live BW and after different production systems. However, Sen et al. (2004) verified that dressing yield expressed in terms of empty live BW was not significantly different between sheep and goats under semiarid conditions. Apparently these differences arise from comparing goats and sheep which are raised under different systems and subjected to different fasting periods before slaughter. There was no significant difference in dressing percentage between males and females (Table 2). In the present study, carcass fatness expressed as KKPF proportion in CCW was not affected by species ($P > 0.05$), but females had greater KKPF proportion ($P < 0.01$) than males (Table 2). Differences between sheep and goats in partitioning of body fat have been reported by others (Mahgoub and Lodge, 1998; Hadjipanayiotou and Koumas, 1994; El Khidir et al., 1998). The authors showed that goats tend to deposit most of their fat internally in mesenteries, kidneys, and alimentary tract, whereas more fat in sheep is deposited in the carcass. Kids present superior linear and circumference measurements (Table 2). Males had greater anterior ($P < 0.05$) and posterior buttock ($P < 0.01$) circumferences and long leg measurements ($P < 0.05$; Table 2). These differences can be attributed to the small differences in slaughter live BW between species and sexes (Table 1). Goat carcasses generally have poorer conformation than sheep carcasses, especially early in life (Morand-Fehr, 1981; Naudé and Hofmeyr, 1981). In the current study, there were no significant differences between species and sexes in carcass compactness index at this maturity stage. Lambs had greater proportions of the highly valued leg cut and lower proportions of shoulder, anterior rib, and neck cuts than kids (Table 3). Similarly, Naudé and Hofmeyr (1981) found that the proportion of the high-priced leg cut in the Boer goat was significantly lower than that in sheep of comparable carcass weight. In the current study, sex difference for wholesale cuts tended to be small and mostly nonsignificant (Table 3). Tissue carcass percentages obtained by dissection of left half carcass cuts are presented in Tables 4 and 5. Dissection results indicated that kid and lamb carcasses had more than 60% of dissectible lean, about 21.0 to 21.8% of bone content and 12.9 to 16.9% of dissectible fat (Tables 4 and 5). These dissection results are in agreement with those obtained by Dhanda et al. (1999) with Capretto carcasses and by Sañudo et al. (2000) with suckling lambs (shoulder dissection). However, in the present study, kid carcasses had greater muscle content ($P < 0.001$) and lower dissected fat ($P < 0.001$) and bone ($P < 0.05$) than lambs (Tables 4 and 5). In all the cuts, muscle proportions were greater for kids than for lambs, but significant differences were not detected in rib and anterior rib cuts (Table 4). The present study confirmed reports that goats are leaner than sheep (Naudé and Hofmeyr, 1981; Devendra and Burns, 1983; Mahgoub and Lodge, 1998). At this

Table 2. Least squares means (±SE) of carcass characteristics of male and female kids and lambs

Item[1]	Species (Sp)		Sex		Significance		
	Kids (n = 55)	Lambs (n = 57)	Female (n = 57)	Male (n = 55)	Sp	Sex	Sp × sex
Traits							
Dressing percentage (CCW basis), %	47.8 ± 0.39[b]	49.3 ± 0.39[a]	48.3 ± 0.39	48.8 ± 0.39	**	NS	NS
KKPF $\cdot$CCW^{-1}, %	2.3 ± 0.12	2.3 ± 0.12	2.6 ± 0.13[a]	2.1 ± 0.12[b]	NS	**	NS
Carcass measurements							
Chest circumferences, cm	48.4 ± 0.55[a]	44.5 ± 0.54[b]	45.7 ± 0.55	47.2 ± 0.54	***	NS	NS
Anterior buttock circumferences, cm	35.6 ± 0.54[a]	33.1 ± 0.53[b]	33.5 ± 0.54[b]	35.3 ± 0.53[a]	**	*	NS
Posterior buttock circumferences, cm	46.6 ± 0.55[a]	37.6 ± 0.51[b]	37.6 ± 0.54[b]	46.6 ± 0.53[a]	***	***	NS
Carcass internal length (L), cm	44.2 ± 0.51[a]	40.9 ± 0.50[b]	42.1 ± 0.51	43.0 ± 0.50	***	NS	NS
Long leg length, cm	30.0 ± 0.29[a]	27.9 ± 0.28[b]	28.5 ± 0.29[b]	29.5 ± 0.28[a]	***	*	NS
Carcass compactness index (CCW $\cdot$L^{-1})	10.8 ± 0.33	10.5 ± 0.32	10.2 ± 0.33	11.1 ± 0.32	NS	NS	NS

[a,b]Within a row, species or sex least squares means without a common superscript letter differ ($P < 0.05$).
[1]CCW = cold carcass weight; KKPF = kidney knob and pelvic fat.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

maturity stage, differences in bone distribution between kids and lambs were low (less 2%) despite the high proportions of bone reported for goat carcasses compared with those of sheep (Naudé and Hofmeyr, 1981; Gaili and Ali, 1985). Irrespective of species, the loin cut had the greatest proportion of muscle (Table 4), and the breast cut had the greatest proportion of intermuscular fat (Table 5). In the present study, kid carcasses had significantly greater muscle:bone ratio than lambs (3.1 vs. 2.8, respectively). This was due to the fact that kids had proportionately more muscle tissue than lambs (64.8 vs. 61.2), whereas the bone difference between kids and lambs tended to be small (21.0 vs. 21.8). At the same stage of maturity, sex had little effect on carcass composition (Tables 4 and 5). In our study, the small differences observed among sexes in dissected fat can be explained by the low slaughter age or weight, because more evident differences might be expected at advanced slaughter age or weight.

Meat Quality Attributes

Species had no effect on muscle pH measured 60 min after slaughter, but when the measurement was made 24 h postmortem, the kids had significantly greater pH values (Table 6). The pH_{24} was similar to that of other suckling lamb breeds such as Manchego (Díaz et al., 2005) or suckling kids of the Canary Caprine group (Marichal et al., 2003). No significant differences were observed between sexes on meat traits, with pH_{24} exception (Table 6). Muscle color is extremely important in suckling lamb and kid production, whose carcasses should be pale or pink. In the present study, the lightness values (46.0 to 47.3) are indicative of extremely pale meats (Table 6). The kid meat was significantly lighter and less yellow than the lamb meat (Table 6). These results are in agreement with Sheridan et al. (2003), who analyzed the LM for color measurement of Boer goat kids and mutton merino lambs finished under feedlot conditions. In the present study, the redness of muscle was not influenced by species (Table 6), although goat meat color tends to be darker red than lamb and mutton meat (Babiker et al., 1990; Sheridan et al., 2003). Kid meat presented less cooking losses ($P < 0.001$) than lamb meat (Table 6). This result is in agreement with the findings of Babiker et al. (1990), who reported that chevon had significantly less cooking losses than lamb. However, Sen et al. (2004) and Lee

Table 3. Least squares means (±SE) of cut percentages of male and female kids and lambs

Item, %	Species (Sp)		Sex		Significance		
	Kids (n = 55)	Lambs (n = 57)	Female (n = 57)	Male (n = 55)	Sp	Sex	Sp × sex
Leg	25.1 ± 0.16[b]	27.7 ± 0.15[a]	26.4 ± 0.16	26.4 ± 0.15	***	NS	NS
Shoulder	22.6 ± 0.15[a]	21.6 ± 0.15[b]	22.0 ± 0.15	22.2 ± 0.15	***	NS	NS
Chump	8.3 ± 0.09	8.2 ± 0.09	8.4 ± 0.09[a]	8.2 ± 0.09[b]	NS	*	NS
Loin	10.5 ± 0.11	10.3 ± 0.10	10.5 ± 0.11	10.4 ± 0.10	NS	NS	NS
Rib	6.6 ± 0.07	6.7 ± 0.07	6.7 ± 0.07[a]	6.5 ± 0.07[b]	NS	*	NS
Anterior rib	5.7 ± 0.07[a]	5.3 ± 0.06[b]	5.5 ± 0.07	5.4 ± 0.06	***	NS	NS
Breast	11.6 ± 0.17	11.3 ± 0.17	11.3 ± 0.17	11.5 ± 0.17	NS	NS	NS
Neck	9.7 ± 0.11[a]	8.8 ± 0.11[b]	9.1 ± 0.11	9.3 ± 0.11	***	NS	NS
Higher-priced[1]	43.9 ± 0.14[b]	46.3 ± 0.14[a]	45.3 ± 0.14[a]	44.9 ± 0.14[b]	***	*	NS

[a,b]Within a row, species or sex least squares means without a common superscript letter differ ($P < 0.05$).
[1]Includes leg, loin, and chump cuts.
*$P < 0.05$; *** $P < 0.001$.

Table 4. Least squares means (±SE) of muscle and bone tissue percentages and ratios of male and female kids and lambs

	Species (Sp)		Sex		Significance		
Item	Kids (n = 55)	Lambs (n = 57)	Female (n = 57)	Male (n = 55)	Sp	Sex	Sp × sex
Muscle, %							
Leg	68.7 ± 0.25[a]	65.1 ± 0.24[b]	67.2 ± 0.25[a]	66.5 ± 0.24[b]	***	*	NS
Shoulder	65.2 ± 0.30[a]	62.0 ± 0.29[b]	63.7 ± 0.30	63.5 ± 0.29	***	NS	NS
Chump	66.8 ± 0.44[a]	61.3 ± 0.43[b]	64.4 ± 0.44	63.7 ± 0.43	***	NS	NS
Loin	72.1 ± 0.54[a]	65.8 ± 0.53[b]	69.2 ± 0.54	68.8 ± 0.53	***	NS	NS
Rib	59.2 ± 0.68	58.9 ± 0.67	59.2 ± 0.68	58.9 ± 0.67	NS	NS	NS
Anterior rib	62.6 ± 0.53	61.6 ± 0.52	62.2 ± 0.53	61.9 ± 0.52	NS	NS	NS
Breast	53.5 ± 0.60[a]	49.6 ± 0.59[b]	52.3 ± 0.60	50.8 ± 0.59	***	NS	NS
Neck	63.0 ± 0.54[a]	57.9 ± 0.53[b]	60.5 ± 0.54	60.3 ± 0.53	***	NS	NS
Carcass	64.8 ± 0.34[a]	61.2 ± 0.33[b]	63.3 ± 0.34	62.7 ± 0.33	***	NS	NS
Bone, %							
Leg	23.2 ± 0.26[b]	24.2 ± 0.25[a]	23.5 ± 0.26	24.0 ± 0.25	**	NS	NS
Shoulder	22.4 ± 0.25[b]	24.2 ± 0.25[a]	23.1 ± 0.25	23.6 ± 0.25	***	NS	NS
Chump	17.4 ± 0.30	17.5 ± 0.29	17.4 ± 0.30	17.6 ± 0.29	NS	NS	NS
Loin	14.8 ± 0.35	14.8 ± 0.34	14.8 ± 0.35	14.9 ± 0.34	NS	NS	NS
Rib	22.7 ± 0.44[a]	21.1 ± 0.43[b]	21.8 ± 0.44	21.9 ± 0.43	**	NS	NS
Anterior rib	22.4 ± 0.38	22.1 ± 0.37	21.9 ± 0.38	22.6 ± 0.37	NS	NS	NS
Breast	20.2 ± 0.40	20.1 ± 0.39	20.1 ± 0.40	20.1 ± 0.39	NS	NS	NS
Neck	20.3 ± 0.47[b]	23.3 ± 0.46[a]	21.6 ± 0.47	22.0 ± 0.46	***	NS	NS
Carcass	21.0 ± 0.24[b]	21.8 ± 0.23[a]	21.2 ± 0.24	21.6 ± 0.23	*	NS	NS
Muscle:bone							
Leg	3.0 ± 0.04[a]	2.7 ± 0.03[b]	2.9 ± 0.04	2.8 ± 0.03	***	NS	NS
Shoulder	2.9 ± 0.03[a]	2.6 ± 0.03[b]	2.8 ± 0.03	2.7 ± 0.03	***	NS	NS
Chump	3.9 ± 0.07[a]	3.6 ± 0.07[b]	3.8 ± 0.07	3.7 ± 0.07	**	NS	NS
Loin	5.0 ± 0.13[a]	4.6 ± 0.12[b]	4.8 ± 0.13	4.8 ± 0.12	*	NS	NS
Rib	2.6 ± 0.06[b]	2.9 ± 0.05[a]	2.8 ± 0.06	2.7 ± 0.05	***	NS	NS
Anterior rib	2.8 ± 0.06	2.8 ± 0.06	2.9 ± 0.06	2.8 ± 0.06	NS	NS	NS
Breast	2.7 ± 0.33	2.9 ± 0.33	2.6 ± 0.33	2.9 ± 0.33	NS	NS	NS
Neck	3.2 ± 0.07[a]	2.6 ± 0.07[b]	2.9 ± 0.07	2.8 ± 0.07	***	NS	NS
Carcass	3.1 ± 0.03[a]	2.8 ± 0.03[b]	3.0 ± 0.03	2.9 ± 0.03	***	NS	NS

[a,b]Within a row, species or sex least squares means without a common superscript letter differ ($P < 0.05$).
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Table 5. Least squares means (±SE) of dissected fat percentages of the male and female kids and lambs

	Species (Sp)		Sex		Significance		
Item	Kids (n = 55)	Lambs (n = 57)	Female (n = 57)	Male (n = 55)	Sp	Sex	Sp × sex
Subcutaneous fat, %							
Leg	2.8 ± 0.19[b]	5.0 ± 0.19[a]	3.8 ± 0.19	4.1 ± 0.19	***	NS	NS
Shoulder	4.5 ± 0.24[b]	5.2 ± 0.24[a]	4.8 ± 0.24	4.9 ± 0.24	*	NS	NS
Chump	7.0 ± 0.42[b]	11.0 ± 0.41[a]	8.6 ± 0.42	9.3 ± 0.41	***	NS	NS
Loin	5.1 ± 0.37[b]	8.7 ± 0.36[a]	6.6 ± 0.37	7.2 ± 0.36	***	NS	NS
Rib	3.5 ± 0.28[b]	5.8 ± 0.28[a]	4.5 ± 0.28	4.8 ± 0.28	***	NS	NS
Breast	7.7 ± 0.20[a]	0.1 ± 0.20[b]	3.7 ± 0.20	4.0 ± 0.20	***	NS	NS
Neck	1.0 ± 0.19[b]	4.0 ± 0.19[a]	2.2 ± 0.19[b]	2.8 ± 0.19[a]	***	*	NS
Carcass	4.1 ± 0.22[b]	6.0 ± 0.22[a]	4.9 ± 0.22	5.2 ± 0.22	***	NS	NS
Intermuscular fat, %							
Leg	4.7 ± 0.17[b]	5.7 ± 0.16[a]	5.2 ± 0.17	5.2 ± 0.16	***	NS	NS
Shoulder	7.2 ± 0.23[b]	8.6 ± 0.23[a]	8.0 ± 0.23	7.7 ± 0.23	***	NS	NS
Chump	8.0 ± 0.25[b]	10.2 ± 0.25[a]	9.1 ± 0.25	9.1 ± 0.25	***	NS	NS
Loin	7.3 ± 0.34[b]	10.7 ± 0.34[a]	9.1 ± 0.34	8.9 ± 0.34	***	NS	NS
Rib	12.0 ± 0.57[b]	14.3 ± 0.56[a]	13.0 ± 0.57	13.3 ± 0.56	**	NS	NS
Anterior rib	12.1 ± 0.53[b]	16.3 ± 0.52[a]	14.5 ± 0.53	14.0 ± 0.52	***	NS	NS
Breast	17.4 ± 0.55[b]	21.9 ± 0.54[a]	19.5 ± 0.55	19.8 ± 0.54	***	NS	NS
Neck	10.8 ± 0.54[b]	14.8 ± 0.53[a]	13.2 ± 0.54	12.4 ± 0.53	***	NS	NS
Carcass	8.8 ± 0.29[b]	10.9 ± 0.28[a]	9.9 ± 0.29	9.8 ± 0.28	***	NS	NS

[a,b]Within a row, species or sex least squares means without a common superscript letter differ ($P < 0.05$).
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Table 6. Least squares means (±SE) of meat quality attributes of male and female kids and lambs

	Species (Sp)		Sex		Significance		
Item[1]	Kids (n = 55)	Lambs (n = 57)	Female (n = 57)	Male (n = 55)	Sp	Sex	Sp × sex
pH_1	6.5 ± 0.03	6.6 ± 0.03	6.6 ± 0.03	6.6 ± 0.03	NS	NS	NS
pH_{24}	5.8 ± 0.02[a]	5.6 ± 0.02[b]	5.6 ± 0.02[b]	5.7 ± 0.02[a]	***	*	NS
L* (lightness)	47.3 ± 0.49[a]	46.0 ± 0.48[b]	46.5 ± 0.49	46.8 ± 0.48	*	NS	NS
a* (redness)	17.0 ± 0.28	16.5 ± 0.28	17.0 ± 0.28	16.5 ± 0.28	NS	NS	NS
b* (yellowness)	5.2 ± 0.15[b]	11.1 ± 0.15[a]	8.3 ± 0.15	8.0 ± 0.15	***	NS	NS
Shear force value, $kg{\cdot}cm^{-2}$	7.7 ± 0.31[b]	9.0 ± 0.29[a]	8.3 ± 0.30	8.4 ± 0.30	**	NS	NS
Cooking loss, %	11.1 ± 0.40[b]	14.3 ± 0.38[a]	13.0 ± 0.39	12.4 ± 0.39	***	NS	NS
Dry matter, %	23.6 ± 0.10[b]	24.3 ± 0.10[a]	24.1 ± 0.10	23.8 ± 0.10	***	NS	NS
Fat, %	1.0 ± 0.07[b]	2.1 ± 0.07[a]	1.7 ± 0.07	1.4 ± 0.07	***	NS	NS

[a,b]Within a row, species or sex least squares means without a common superscript letter differ ($P < 0.05$).

[1]pH_1 = pH 1 h postmortem; pH_{24} = pH 24 h postmortem.

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

et al. (2007) found no significant differences between sheep and goat meat in cooking losses.

In general, shear force values of kid and lamb meat were high (Table 6) when compared with shear force values reported in other studies with kid (Marichal et al., 2003) or lamb (Velasco et al., 2000) meat evaluated in similar conditions. The Warner-Bratzler shear force values of lamb meat beyond 5.5 kg are often be considered as objectionably tough both by a trained sensory panel and the consumers (Webb et al., 2005); however, these values are based on a core size and shape different for that used in the present study. Because of the smaller size and lack of subcutaneous fat coverage, low-weight carcasses of kids and lambs dissipate heat at a rapid rate during the immediate postmortem period. This rapid cooling rate of carcasses may cause cold shortening, a phenomenon that results in lower tenderness of meat (Kannan et al., 2006). Shear force value was, however, significantly greater ($P < 0.01$) in lamb meat. This result opposes those who found shear force value was significantly greater in goat meat (Sen et al., 2004; Lee et al., 2007), but these studies were conducted with greater slaughter age or weight, and goats and sheep were reared under different production systems.

The kid meat had significantly more moisture and less intramuscular fat content than lamb (Table 6). These results are in close agreement with the findings of Babiker et al. (1990) and Sen et al. (2004). The chemical composition of the LM was similar to that found by Marichal et al. (2003) in LM of Canary Caprine group kids. According to Wood (1990), 2 to 3% of intramuscular fat is needed to ensure the organoleptic qualities of meat; therefore, lambs potentially presented a better intramuscular fat distribution.

At this maturity stage, there were significant differences on both carcass and meat quality attributes of suckling kids and lambs, possibly due to inherent species distinctions, but sensory analysis of kid and lamb meat should be considered in further investigation. Relative to meat quality attributes, with special focus on tenderness, it seems that low-weight carcasses of kids and lambs should be handled carefully to retain the meat tenderness. Carcasses chilled slowly or electrical stimulations before chilling were pointed out as very effective to improve meat tenderness (McMillin and Brock, 2005; Devine et al., 2006) and must be considered in future research with low-weight kid and lamb carcasses.

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