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Effects of genotype and slaughter weight on the meat quality of Criollo Cordobes and Anglonubian kids produced under extensive feeding conditions

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ABSTRACT

Physicochemical and organoleptic characteristics of meat (*longissimus* muscle) from Criollo Cordobes (CC) and Anglonubian (AN) suckling kids were analysed to determine the effects of genotype and slaughter weight. Forty suckling entire male kids, 20 CC and 20 AN were assigned to two age/slaughter weight groups (I: 60 + 2 days old and ⩽11 kg, and II: 90 + 2 days old and >11 kg). Colour, shear force and cholesterol levels of meat were affected by breed. Tenderness decreased and cholesterol increased with age/slaughter weight. Fatty acid profiles were affected primarily by genotype. The sensory attributes were perceived as medium-high intensity, and meat from CC and AN goat kids was valued as tender. However, initial tenderness and connective tissue varied with genotype. The main effect due to the increase in age/slaughter weight was a decrease in tenderness (initial and overall), as observed for instrumental shear force.

1. Introduction

Meat quality is important for consumers when it comes to making purchasing decisions. Meat from goats has gained acceptance mainly because of its low-fat content, especially in developed countries. Also, cholesterol content (62–65 vs 73–78 mg/85 g meat) and saturated fatty acid levels (0.79–1.01 vs 6.8–8.7 g/85 g meat) of cooked goat meat are lower when compared to other red meats (USDA, 1989). The content and the amount of fatty acid saturation can affect the human health and the degree of fat firmness, which influences the value and acceptability of meat products (Perry, Nicholls, & Thompson, 1998). On the other hand, the colour, tenderness and sensory properties are important in affecting meat acceptability. Several reports have been published on the characteristics of goat meat and factors that influence its composition and acceptability (Park & Washington, 1993; Cifuni, Napolitano, Pacelli, Riviezzi, & Girolami, 2000; Velasco et al., 2001).

The Argentinean goat population is approximately 4.4 million (SAGPyA, 2005) distributed throughout the country but located primarily (55% of the total livestock) in the north and central zones. The central provinces, such as Cordoba (approximately 174,000 goats), are important goat meat producing areas. Criollo Cordobes (CC) goats represent a local genotype obtained by adaptation of the Creole goats (Maubecin, 1976) to the environmental conditions of Cordoba, it is the most common goat breed in this region (70%), and its main commercial product is the kid. Currently milk production increased after the introduction of dairy breeds, mainly Anglonubian (AN), whose male kids are destined for meat production (Maubecin, 1976). Therefore the main sources of goat meat in Argentina are CC and AN goat kids. Traditionally, kids have been slaughtered at 3–7 months old and 12–15 kg carcass weight. Recently, the market demands younger animals (30–65 days old and 6–11 kg liveweight; Arias & Alonso, 2002), because the meat from these young suckling kids is considered a delicacy. However, Sormunen-Cristina and Kangasmäki (2000) suggested that the best goat meat is produced by 3–6 month old kids, whose meat is nearly fatless and light in colour. However, meat characteristics of these two breeds, as well as the effects of reducing their age/weight at slaughter, have not been studied to date.

Therefore, the objective of this study was to determine the effects of genotype and slaughter weight on the physicochemical and organoleptic characteristics of meat from CC and AN kids.

2. Materials and methods

2.1. Animal management

The study was conducted at the Faculty of Agronomy and Veterinary (University National of Rio Cuarto, Cordoba, Argentina) (latitude 29–35°S, and longitude 61–65°O).

On the basis of weight and age, a total of 40 entire male goat kids (20 CC and 20 AN) were selected at weaning (60–90 days of age and 9–13 kg of live weight) from two commercial goat farms

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in Cordoba (Argentina). Adults were fed on pastures without concentrate supplements (extensive system). Kids were reared according to the traditional system of the region: kept with their does and suckling until slaughter. Kids were assigned to one of two groups: I (60 + 2 days old and $\geqslant$11 kg) and II (90 + 3 days old and >11 kg). When kids reached the predetermined age/slaughter weight, they were separated from their dams and transported to the abattoir (5 km away). Immediately after arrival at the abattoir, kids were kept in covered yards and then fasted for 12 h with free access to water. Kids were weighed immediately prior to slaughter (live weight at slaughter; LWS), stunned using a captive bolt pistol and dressed according to method of Colomer-Rocher, Fehr, Delfa, and Sierra (1988). Warm carcasses were weighed (hot carcass weight; HCW), hung by the Achilles' tendon, held at room temperature (12 ± 2 °C) for 6 h, to avoid cold shortening, and then chilled at 2 °C (±2 °C) until 24 h *post-mortem*. The gastro-intestinal content was weighed, and empty body weight (EBW) was calculated by deducting the weight of digesta from the fasted live weight at slaughter. Hot dressed yield (HDY) was calculated as (HCW/EBW) × 100. After chilling, the carcasses were split down the dorsal midline, and *longissimus thoracis et lumborum* (LTL) muscle was removed from the left side of carcasses, and separately vacuum packaged, aged for 72 h and frozen and stored at −20 °C for up to 1 week, prior physicochemical and sensory evaluations. The day before the analysis, the samples were thawed overnight at 4–5 °C.

2.2. Physical analysis

Before packaging, meat colour and pH were determined from the LTL muscle at 8 ± 2 °C. The ultimate pH values (pH_{24}, measured at 24 h after slaughter) was measured directly in LTL muscle (at the 12–13th rib site) using a penetrating glass electrode connected to a portable CRISON 506 pH-meter (Crison Instruments, SA, Barcelona, Spain). Three measurements were taken for each carcass. Muscle colour was evaluated at the same site as for pH_{24} and after cutting the muscle surface to allow it to bloom for 1 h at 3 °C in a plastic tray covered with a gas permeable film. Then three colour was measurements were taken, using the CIE-L^*, a^*, b^* system, by a chromometer (ByK Gardner Colour View, model 9000, USA) following the recommendations (standard illuminant D65 and 10° standard angle observer) of AMSA (1991). Chroma or saturation ($(a^{*2} + b^{*2})^{1/2}$) was calculated using a^* and b^* values according to Wyszecki and Stiles (1982). Values were registered from three different locations on the upper side of the steaks. *Longissimus thoracis* (LT) and *longissimus lumborum* (LL) muscles were collected for subsequent physicochemical and sensory analysis, respectively.

Water holding capacity (WHC), expressed as percentage of liquid expelled, was determined following the filter paper press methodology described by Zamorano and Gambaruto (1997). For determination of cooking loss and shear force (WBS) values, samples were weighed and then cooked into a plastic bag in a water bath at 75 °C until an internal temperature of 71 °C was achieved. After cooling, the samples were taken from the bags, dried with filter paper and reweighed. Cooking loss was expressed as the percentage loss related to the initial weight. Then 3–5 muscle cores (1 cm × 1 cm × 3 cm) were cut parallel to the long axis of the muscle fibres, and WBS values were taken on the cores using an Instron apparatus (Instron Ltd., UK) equipped with a Warner–Bratzler shear device, as in AMSA (1995). The texture analyzer was set with a 25 kg load cell and a crosshead speed of 200 mm/min.

2.3. Cholesterol and fatty acid analysis

Total intramuscular fat (IMF) content of LT muscle (from 10 g of meat) was determined according to official methods (AOAC, 1992) by using a Tekator analyzer (Foss Tekator AB Soxtec 2050). IMF for fatty acid and cholesterol determinations was extracted (from 5 g of meat) as described by Folch, Lees, and Stanley (1957). Total cholesterol was measured after saponification with 4% KOH in ethanol absolute, using an enzymatic and colorimetric reactive (BioSystem S.A.). Fatty acid methyl esters were prepared according to the method of Pariza, Park, and Cook (2001) and measured using a chromatograph (Chrompack CP 900) equipped with a flame ionization detector and fitted with a silica capillary column CP-Sil 88 (100 m, 0.25 mm i.d., 0.2 μm film thickness, Chrompack Inc., Middleburg, The Netherlands), using N_2 as carrier gas (2.5 psi). The oven temperature was programmed at 70 °C for 4 min, increased from 70 to 170 °C at a rate of 13 °C/min and then increases from 170 to 200 °C at 1 °C/min. The injection port and detector temperature were maintained at 250 °C. Tricosanoic acid methyl ester (C23:0 ME) at 10 mg/ml was used as an internal standard. Individual fatty acids were identified by comparing their retention times with those of an authenticated standard fatty acid mix Supelco 37 (Sigma Chemical Co. Ltd., Poole, UK). Individual fatty acids were corrected by their relative response factor (using the value of the internal standard) and expressed as a percentage of total fatty acids identified. Fatty acids were grouped as follows: saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA). The following ratios were calculated: PUFA/SFA, $n-6/n-3$ and 18:0 + 18:1/16:0.

2.4. Sensory analysis

Sensory evaluation was carried out on whole LL muscle (~100 g) samples by six trained panellists. Samples were cooked using the same cooking method as for shear force measurements. Every steak was then trimmed of any external connective tissue, cut into approximately 1 × 1 cm sub-samples, transferred into a pre-warmed glass beaker, covered and placed into an oven at 60 °C to equilibrate their temperature prior to being served. Samples were coded and the serving sequence was randomised. The attributes were assessed using a nine-point scale (IRAM, 1985; AMSA, 1995) for flavour intensity (9 = extremely intense; 1 = extremely bland); initial and overall tenderness (9 = extremely tender; 1 = extremely tough); juiciness (9 = extremely juicy; 1 = extremely dry); aroma (9 = extremely desirable; 1 = extremely undesirable); and amount of connective tissue (9 = no perceptible; 1 = abundant perceptible).

2.5. Statistical analysis

The effects of genotype and slaughter weight group on meat quality and fatty acid profiles of intramuscular fat were analysed by ANOVA using the General Linear Model (GLM) procedures of the Statistica statistical package (Statistica, 2001). No significant genotype by slaughter weight interaction was noted for the parameters evaluated in this study. Therefore only main effects have been presented and discussed.

3. Results and discussion

3.1. Carcass quality

Table 1 shows LWS, EBW, HCW and HDY values for CC and AN kids. Similar results have previously been reported for suckling kids in Argentina (Gallinger, Dayenoff, & Garriz, 1994; Rossanigo, Frigerio, & Silva Colomer, 1996; Leguiza, Chagra, & Vera, 2001; De Gea, Petryna, Mellano, Bonvillani, & Turiello, 2005; Domingo, Abad, Lanari, & Bidinost, 2008; Zimerman, Domingo, & Lanari, 2008). However, HDY values reported in this study were higher than those reported by other authors (Johnson, McGowan, Nurse,

& Anous, 1995; Dhanda, Taylor, & Murray, 2003a; Marichal, Castro, Capote, Zamorano, & Argüello, 2003). An increase in HDY with increasing slaughter weight has been noted in both breeds, in agreement with Marichal et al. (2003), although the differences were not statistically significant ($p > 0.05$) in the present study.

Significant differences between genotypes were observed for HDY, in agreement with Dhanda et al. (2003a). The kids of AN genotype had higher ($p < 0.01$) HDY than CC genotype. These differences could be attributed to a higher milk production from their mothers and therefore higher growth rate and fatness. Pralomkarn, Saithanoo, Kochapakdee, and Norton (1995) found an effect of nutrition on HDY which increased with increasing feed intake.

3.2. Meat quality

Table 1 shows the mean values and standard errors for meat quality parameters according to breed and slaughter weight. The pH_{24} of LTL muscle of kids from two genotypes, with an average value of 5.73, was high but in the acceptable range (Hedrick, Aberle, Forrest, Judge, & Merkel, 1994). The meat colour from CC and AN kid goats, with values for L^*, a^* and b^* similar to those obtained by Madruga et al. (2008) and Lee, Kouakou, and Kannan (2008), can be valued or classified as pale red. L^*, a^* and WBS were affected by genotype, in agreement with Simela, Webb, and Frynlinck (2004), who studied indigenous South African goat breeds. AN kids meat was slightly ($p < 0.001$) higher lightness and lower redness than the CC kids meat, with higher L^* and lower a^* values. This could be related to its higher water retention capacity, since pH_{24} values were similar from meat of CC and AN kids. Similar to the findings in the present study, a significant effect of genotype on goat meat colour has been reported by Dhanda et al. (2003a) and Madruga et al. (2008). There were no significant differences ($p > 0.05$) among breeds in chroma values.

The effect of LWS (Table 1) was not significant for muscle colour values, in agreement with Nuñez Gonzalez, Owen, Cereceres, and Maria (1983) and Todaro et al. (2002). Marichal et al. (2003) found a slight decrease of L^* with increased body weight and attribute it to his close relationship with changes in ultimate pH. The chroma values of the LTL muscle increased ($p > 0.05$) with LWS, in agreement with Marichal et al. (2003) and Simela, Webb, and Frylinck (2004). Generally, as maturity increases, muscle colour becomes darker in goats.

Tenderness, evaluated as the maximum shear force necessary to cut the meat perpendicular to the fibres, ranged 59.7–80.6 N/cm^2. These values were similar to those reported by Johnson et al. (1995) in the adult Florida native goat and its crosses with Nubian and Spanish breeds, and Marichal et al. (2003) in Canary Caprine Group, and are within range of values reported in other studies (Nuñez Gonzalez, Owen, Cereceres, & Maria, 1983; Babiker, El Khider, & Shafie, 1990; Dhanda et al., 2003a; Santos et al., 2007). The evaluation of factors affecting meat tenderness is particularly important in goat meat because of its lower tenderness than sheep and beef (Johnson et al., 1995). Genotype had a significant effect on WBS values, in agreement with results reported by Simela et al. (2004). Muscle shear force values from AN kids were higher than those from CC kids (79.2 N/cm^2 vs. 62.9 N/cm^2). A decrease in tenderness with increasing slaughter weight has been noted in both breeds, in agreement with Dhanda et al. (2003a) and Marichal et al. (2003), although the differences among weights were not statistically significant.

Water holding capacity (WHC) is a term originally used to describe the ability of muscle to bind water under a set of conditions and, therefore, always linked to sensory properties of meat such as juiciness and flavour. As shown in Table 1, WHC, with an average value of 30.5%, was not affected by genotype. In contrast, Madruga et al. (2008) found significant differences among genotypes (Moxotó and Canindé) in WHC. These values were slightly lower than those observed by Sañudo et al. (1995) in adult Spanish goats and Marichal et al. (2003) in Canary Caprine Group breed, and similar to those found by Argüello, Ginés, Capote, and López (1999), and Bañón, Vila, Price, Ferrandini, and Garrido (2006) in Canary Caprine Group kids and Murciano-Granadina kids, respectively. These results show that CC and AN kids have a high WHC, typical of the meat of young animals (Todaro et al., 2002). A decrease in WHC with an increase in slaughter weight of kids has been noted (Marichal et al., 2003). In the present experiment, we found an opposite trend, but the differences are not statistically significant. This difference might be due to the lower range of weights for slaughter in our study (9–13 kg vs. 6–25 kg), because these authors found increases of WHC in kids slaughtered 6–15 kg.

Cooking loss ranged from 25.0% to 28.8%, which is within the normal range for goat meat (Dhanda et al., 2003a; Todaro et al., 2004) and shows no difference between breeds. In the present study, the percentage of cooking loss was similar between Group I and Group II in disagree with Dhanda et al. (2003a), who recorded higher cooking losses in Chevon (28 kg) compared to Capretto (16 kg).

3.3. Fatty acid composition

Table 2 presents the mean values and standard errors of IMF and cholesterol levels and the fatty acid main indices of the LT muscle from CC and AN kids. IMF contents in both genotypes were within 1.2 and 1.3 g/100 g muscle. These values were similar to

Table 1
Carcass characteristics and instrumental meat quality of *longissimus* muscle from Criollo Cordobes and Anglonubian kids.

	Criollo Cordobes		Anglonubian		*p* values	
	Group I	Group II	Group I	Group II	Breed	Weight
LWS (kg)	10.44 ± 0.36	11.72 ± 0.24	10.15 ± 0.18	11.29 ± 0.15	0.317	0.001
EBW (kg)	9.04 ± 0.26	10.26 ± 0.19	8.98 ± 0.48	10.04 ± 0.06	0.293	0.001
HCW (kg)	4.98 ± 0.27	5.65 ± 0.38	5.18 ± 0.18	5.79 ± 0.16	0.077	0.031
HDY (%)	54.5 ± 0.51	55.7 ± 0.62	58.1 ± 0.64	59.4 ± 0.72	0.008	0.297
pH	5.75 ± 0.03	5.72 ± 0.02	5.74 ± 0.03	5.71 ± 0.03	0.779	0.326
L^*	42.54 ± 0.88	42.85 ± 0.83	48.82 ± 0.68	47.14 ± 0.75	0.001	0.392
a^*	10.78 ± 0.36	10.48 ± 0.42	8.19 ± 0.40	9.33 ± 0.19	0.001	0.280
b^*	15.23 ± 0.62	15.67 ± 0.46	15.74 ± 0.42	16.15 ± 0.34	0.303	0.372
Chroma	18.67 ± 0.67	18.91 ± 0.40	17.98 ± 0.44	18.65 ± 0.39	0.247	0.263
WBS (N/cm^2)	59.68 ± 2.45	66.05 ± 5.00	77.81 ± 3.52	80.65 ± 3.14	0.001	0.132
WHC (%)	30.54 ± 0.47	30.55 ± 0.39	30.32 ± 0.79	31.25 ± 0.63	0.241	0.253
Cooking loss (%)	25.36 ± 1.76	25.04 ± 1.50	28.84 ± 1.20	27.42 ± 1.01	0.195	0.111

LWS, live weight at slaughter; EBW, empty body weight; HCW, hot carcass weight; HDY, hot dressing yield; WBS, Warner–Bratzler shear force; and WHC, water holding capacity.

Table 2
Intramuscular fat and cholesterol content, and intramuscular fatty acid indices (% total fatty acids) of *longissimus* muscle from Criollo Cordobes and Anglonubian kids.

	Criollo Cordobes		Anglonubian		*p* values	
	Group I	Group II	Group I	Group II	Breed	Weight
IMF (g/100 g)	1.18 ± 0.15	1.09 ± 0.07	1.32 ± 0.11	1.41 ± 0.04	0.142	0.112
Cholesterol (mg/100 g)	65.98 ± 0.85	59.14 ± 1.07	60.49 ± 2.06	65.86 ± 1.04	0.556	0.124
SFA	40.09 ± 0.61	41.92 ± 0.45	37.91 ± 0.62	37.61 ± 0.41	0.047	0.789
MUFA	36.21 ± 1.04	36.19 ± 0.98	39.06 ± 1.17	38.93 ± 1.08	0.166	0.330
PUFA	22.43 ± 1.06	21.38 ± 1.02	22.02 ± 0.98	22.48 ± 0.83	0.817	0.320
n−6	15.98 ± 0.71	16.18 ± 0.63	17.34 ± 0.64	18.15 ± 0.38	0.148	0.503
n−3	6.15 ± 0.38	5.73 ± 0.41	4.82 ± 0.20	4.63 ± 0.39	0.051	0.346
CLA	1.05 ± 0.23	0.94 ± 0.12	0.83 ± 0.03	0.74 ± 0.14	0.144	0.157
MUFA/SFA	0.89 ± 0.03	0.86 ± 0.04	1.03 ± 0.04	1.04 ± 0.04	0.001	0.473
PUFA/SFA	0.53 ± 0.04	0.52 ± 0.07	0.58 ± 0.03	0.59 ± 0.02	0.302	0.120
n−6/*n*−3	2.58 ± 0.26	2.89 ± 0.21	3.69 ± 0.18	4.04 ± 0.13	0.035	0.434
18:0 + 18:1/16:0	2.20 ± 0.09	2.22 ± 0.09	2.30 ± 0.04	2.30 ± 0.05	0.075	0.481

IMF, intramuscular fat; SFA, saturated fatty acids (C10:0 + C12:0 + C14:0 + C15:0 + C16:0 + C17:0 + C18:0); MUFA, monounsaturated fatty acids (C14:1 + C16:1 + C17:1 + C18:1); PUFA, polyunsaturated (C18:2 + C18:3 + C20:2 + C20:3 + C20:4 + C20:5 + C22:4 + C22:5 + C22:6).

those reported by Marichal et al. (2003) for Canary Caprine Groups kid goats slaughtered at 6 and 10 kg, and lower than those obtained from weaned goats by Bas, Dahbi, El Aich, Morand-Fehr, and Araba (2005) and Talpur, Bhanger, and Sherazi (2008). The differences are possibly due to different breed and feeding practices, as breed and diet are two major factors affecting IMF content (Banskalieva, Sahlu, & Goest, 2000). The LT muscle from CC kids had a lower ($p > 0.05$) IMF percentage compared to that from muscles of AN kids reared in the same environment and slaughtered at similar age/weight. These results are consistent with those obtained by Gibb, Cook, and Treacher (1993) who reported a significant influence of genotype on the fat content of carcasses from male kid goats of several genotypes.

Total cholesterol content from both genotypes ranged from 59.1 mg/100 g to 65.9 mg/100 g muscle (Table 2) and was not affected by genotype and slaughter weight, in agreement with Werdi Pratiwi, Murray, and Taylor (2006a). The cholesterol content did not show a clear trend with the increasing slaughter weigh. They were higher and lower for the heavier CC and AN kids, respectively, compared to the light kids ones. In contrast, Beserra, Madruga, Leite, da Silva, and Maia (2004) reported an increase in cholesterol levels with the age/weight at slaughter. These values are close to the results reported by Bas et al. (2005) in meat from goats raised on rangeland. Other authors have reported lower values, as Santos-Filho et al. (2005) for crossbred goat fed a cashew nut supplemented diet or Bañón et al. (2006) in Murciano-Granadina suckling kids fed with goat milk or milk replacer.

The ratios of PUFA/SFA ranged between 0.5 and 0.6 in LT muscle. Those values were higher than those reported by Werdi Pratiwi et al. (2006a) and Talpur et al. (2008). The *n*−6/*n*−3 ratio values were comparable to those found by Bas et al. (2005) and Talpur et al. (2008), and were lower than those reported by others authors (Vicenti, Ragni, Vonghia, Zezza, & Giannico, 2001; Todaro et al., 2004). De Smet, Raes, and Demeyer (2004) had considered that the *n*−6/*n*−3 ratio is much more affected by feeding than by genotype. On the other hand, the average *n*−6/*n*−3 ratio (3.65) of the intramuscular fats in the present study may be considered appropriate, considering the value recommended for the human diet as a whole (<4.00), while the average PUFA/SFA ratio (0.55) is higher (>0.45) (Enser et al., 1998).

Slaughter weight did not affect ($p > 0.05$) the fatty acids profiles of the LT muscle. These findings are in disagreement with Werdi Pratiwi, Murray, Taylor, and Zhang (2006b) for male kids of the Boer and Australian feral goats slaughtered at 5, 30 and 60 kg. On the other hand, the results obtained by Beserra et al. (2004) after a principal component analysis applied to the fatty acid contents suggests that the variations in fatty acid profiles are mainly due to age/weight at slaughter. These differences could be attributed to the ranges of slaughter weights used in both studies, due to the increased IMF content and the percentage of unsaturated fatty acids at a heavier slaughter weight (De Smet et al., 2004). Also, the change registered by these authors in the profile of fatty acids with increased slaughter weight could be related to the type of feed consumed; the composition of the fatty acid from suckling kids were different to those of the weaned animals (Potchoiba, Lu, Pinkerton, & Sahlu, 1990; Todaro et al., 2002).

The proportions of SFA and *n*−3 and MUFA/SFA and *n*−6/*n*−3 ratios, from samples of LT muscle, were affected by genotype. In general, the proportions of SFA were higher in CC kids than in AN ones. On the other hand, the AN kids displayer a higher proportion of MUFA and greater *n*−6/*n*−3 ratio ($p < 0.01$). These differences could be attributed to the amount and composition of milk received by the kids, as it is generally accepted that the fatty acids profiles of suckling kids are related to that of maternal milk (Zygoyiannis, Kufidis, Katasaounis, & Phillips, 1992; Dhanda, Taylor, Murray, & McCosker, 1999), and increased milk intake in nursing kids leads to decrease saturation of adipose tissue fats. Nevertheless, the PUFA/SFA ratio was similar between genotypes, which disagrees with the results obtained by Sinclair (1982), who reported that the PUFA/SFA ratio was inversely correlated with intramuscular lipid values.

The proportions of desirable fatty acids (18:0 + MUFA + PUFA) ranged within 71.3% and 72.7%, percentages slightly higher than those recorded by Santos et al. (2007), and within the range reported by other authors (Potchoiba et al., 1990; Matsuoka, Furokawa, & Takakashi, 1997; Talpur et al., 2008). It has been suggested that palmitic acid (C16:0) increases blood cholesterol, stearic acid (C18:0) has no effect, and oleic acid (C18:1) decreases blood cholesterol content. Banskalieva et al. (2000) suggested that the ratio of (C18:0 + C18:1)/C16:0 could be useful in describing the potential health effects of different types of lipids. In the present study this ratio was 2.23 for all animals, which was slightly higher than those reported for kids of Serrana, Bravia and Serrana × Bravia genotypes (Santos et al., 2007) and similar to those reported for the Girgentana breed (Todaro et al., 2002), slaughtered at 47 days of age.

Individual fatty acid composition of the LT muscle is presented in Table 3. The main fatty acids identified from the IMF were oleic, palmitic and stearic acids, with percentages between 32.6–35.9%, 20.3–21.4% and 11.3–14.3%, respectively, which accounted about 70% of total fatty acids. That fatty acid composition was in the range of those reported in goats (Banskalieva et al., 2000; Bas et al., 2005), and is in agreement with studies by Rhee, Waldron, Ziprin, and Rhee (2000) and Beserra et al. (2004), among other authors. The oleic acid had the highest percentage compared to other fatty acids, although the values recorded in this study were

Table 3
Intramuscular fatty acid composition (% total fatty acids) of *longissimus* muscle from Criollo Cordobes and Anglonubian kids.

	Criollo Cordobes		Anglonubian		*p* values	
	Group I	Group II	Group I	Group II	Breed	Weight
10:0	0.39 + 0.04	0.49 + 0.05	0.20 ± 0.02	0.28 ± 0.01	0.001	0.201
12:0	0.78 + 0.08	0.65 + 0.03	0.53 ± 0.02	0.56 ± 0.01	0.018	0.828
14:0	3.88 + 0.03	3.52 + 0.08	3.75 ± 0.08	3.96 ± 0.04	0.468	0.896
14:1	0.45 + 0.04	0.29 + 0.05	0.36 ± 0.01	0.26 ± 0.01	0.231	0.604
15:0	0.51 ± 0.03	0.57 ± 0.01	0.44 ± 0.01	0.39 ± 0.01	0.047	0.501
16:0	20.55 ± 0.31	21.41 ± 0.18	20.25 ± 0.08	20.67 ± 0.06	0.061	0.634
16:1	2.27 ± 0.06	2.55 ± 0.06	2.57 ± 0.04	2.35 ± 0.02	0.732	0.419
17:0	1.06 ± 0.05	0.97 ± 0.01	0.72 ± 0.01	0.82 ± 0.02	0.002	0.239
17:1	0.63 ± 0.04	0.67 ± 0.06	0.45 ± 0.02	0.41 ± 0.01	0.005	0.491
18:0	13.53 + 0.33	14.34 + 0.36	12.02 ± 0.13	11.33 ± 0.11	0.031	0.317
18:1 *n*−9	32.89 + 0.41	32.62 + 0.58	35.69 ± 0.28	35.93 ± 0.25	0.077	0.811
18:2 *n*−6	8.36 + 0.18	9.24 + 0.15	8.79 ± 0.04	9.77 ± 0.03	0.195	0.533
18:3 *n*−3	1.45 ± 0.11	1.51 ± 0.03	1.06 ± 0.03	1.21 ± 0.02	0.182	0.695
20:2 *n*−6	0.59 ± 0.06	0.50 ± 0.07	0.55 ± 0.05	0.51 ± 0.03	0.679	0.749
20:3 *n*−6	0.56 ± 0.03	0.48 ± 0.07	0.59 ± 0.02	0.55 ± 0.01	0.835	0.397
20:4 *n*−6	5.57 ± 0.04	5.14 ± 0.07	6.94 ± 0.03	6.73 ± 0.05	0.037	0.601
20:5 *n*−3 (EPA)	1.97 ± 0.03	1.49 ± 0.06	0.92 ± 0.03	0.82 ± 0.03	0.015	0.833
22:4 *n*−6	0.98 ± 0.04	0.68 ± 0.06	0.54 ± 0.02	0.50 ± 0.03	0.030	0.486
22:5 *n*−3 (DPA)	2.17 ± 0.15	1.77 ± 0.05	1.57 ± 0.03	1.44 ± 0.04	0.026	0.595
22:6 *n*−3 (DHA)	0.78 ± 0.11	0.57 ± 0.03	1.12 ± 0.01	0.97 ± 0.01	0.011	0.173

Table 4
Sensory attributes of *longissimus* muscle from Criollo Cordobes and Anglonubian kids.

	Criollo Cordobes		Anglonubian		*p* values	
	Group I	Group II	Group I	Group II	Breed	Weight
Flavour	6.94 ± 0.09	7.28 ± 0.12	6.82 ± 0.12	6.91 ± 0.06	0.659	0.907
Initial tenderness	6.95 ± 0.10	6.61 ± 0.14	6.82 ± 0.08	6.31 ± 0.09	0.053	0.001
Overall tenderness	6.78 ± 0.11	6.58 ± 0.09	6.79 ± 0.07	6.40 ± 0.07	0.337	0.001
Juiciness	5.86 ± 0.19	6.24 ± 0.21	5.19 ± 0.16	5.51 ± 0.16	0.009	0.414
Aroma	7.06 ± 0.09	6.98 ± 0.08	7.18 ± 0.13	6.73 ± 0.03	0.556	0.016
Connective tissue amount	7.02 ± 0.11	7.08 ± 0.10	6.95 ± 0.09	7.02 ± 0.09	0.532	0.972

lower than those obtained by Dhanda, Taylor, and Murray (2003b) from six genotypes, by Rhee et al. (2000) from Boer × Spanish goats, by Bas et al. (2005) from intact male goats of the Moroccan local breed raised on rangeland, or by Werdi Pratiwi et al. (2006b) from Boer and Australian feral goats. These differences are probably due to the use of different goat breeds (De Smet et al., 2004), type of feed (Bas et al., 2005; Lee et al., 2008) or slaughter weight (Sañudo et al., 1998), since a change in diet after weaning and the increase of slaughter weight may change significantly the fatty acid profiles (Dhanda et al., 2003b; Beserra et al., 2004). The proportion of the majority of individual fatty acids studied in LT muscle was affected by genotype, in agreement with Werdi Pratiwi et al. (2006b). However, the content of *n*−6 and CLA fatty acids did not show any difference in relation to genotype of kids.

3.4. Sensory quality of cooked meat

Table 4 presents the mean values and standard errors for the sensory scoring of cooked meat according to breed and slaughter weight. Cooked meat samples from all animals were in the acceptable range, as observed by sensory scores. In the present study, sensory panel scores were similar to reported by Babiker et al. (1990) and Dhanda et al. (2003b), and the sensory attributes were perceived by the members of the panel with medium-high intensity, better scores than those recorded by Germano Costa et al. (2008) in Blanca Serrana Andaluza breed. Breed and slaughter weight had no effect on flavour and connective tissue; similar to findings reported by Dhanda et al. (2003b), Germano Costa et al. (2008) and Madruga et al. (2008). A significant ($p < 0.05$) decrease in initial and overall tenderness with slaughter weight observed in the present study has already been observed by Dhanda et al. (2003b). Significant ($p < 0.05$) effects of genotype on the initial tenderness and juiciness were also observed in the present study. Meat from CC kids showed better scores in both variables. The aroma intensity of samples from CC and AN kids did not differ significantly, although the latter had a higher IMF content.

4. Conclusions

The meat from both genotypes, CC and AN, is pale red, tender, juicy and the intensity of flavour and aroma were medium-high. The fatty acid composition of the LT muscle was significantly affected by breed. However, results suggest that decreasing the slaughter weight from 12 to 10 kg for kids reared with their mothers does not have negative effects on meat quality. In fact, meat from lighter animals was evaluated as more tender by both instrumental and sensory analyses. Therefore, in the circumstances of the study, extensive production system without dietary supplementation, the small increase in live weight does not justify slaughtering the kids with more than 60 days old.

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