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Effects of live weight at slaughter (6, 10 and 25 kg) on kid carcass and meat quality

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Abstract

In Mediterranean countries live weight at slaughter (LWS) for kid goats is lower than in Arabian or African countries. Logically, increasing LWS could increase a farmer's profit margin. Forty-five twin male kids from the Canary Caprine Group breed were used to compare carcass and meat quality at 6, 10 and 25 kg LWS. Dressing percentage based on full weight was lower for 25 kg LWS compared with LWS of 6 and 10 kg, although based on empty body weight dressing percentage for 25 kg LWS was similar to that with 6 and 10 kg LWS. Dressing percentage based on empty body weight was, however, lower for 6 vs. 10 kg LWS. There were no significant differences among LWS in percentage contributions to the whole carcass of primal cuts excluding the neck (lower proportion in 25 kg LWS kids). LWS did not affect tissue distribution in the carcass except for intermuscular fat (higher for 25 vs. 6 kg LWS). Few differences between LWS were observed in relation to meat quality parameters. Results suggest that increasing LWT from 6 to 10 and 25 kg for kids artificially reared does not have negative effects on carcass or meat quality yet would result in more edible meat (pounds) to be marketed.

Keywords: Kids; Carcass; Meat; Quality; Live weight at slaughter

1. Introduction

Naudé and Hofmeyr (1981) described the goat population as comprised of four types, i.e., fiber goats (e.g. Angora, Cashmere), dairy goats (e.g. Saanen, Toggenburg, Nubian), meat goats (e.g. Boer) and feral goats. The world's goat population was around 720 million in 2000, with annual meat production of around 3.7 million metric tonnes. In India, the local community specifically seeks meat from mature goats, whereas in France, Italy and Latin America meat from young milk fed kids is considered a delicacy (Naudé and Hofmeyr, 1981). Acceptability of meat is so much influenced by local custom and preference that it is impossible to apply a universal standard for the quality of goat meat (Naudé and Hofmeyr, 1981). The Canary Caprine Group is a dairy goat population present in Canary Island (Spain) with a mean production of over 500 kg of milk in 210 days of lactation (Fresno et al.,

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1994). Milk quality is high in comparison to other Spanish and international breeds, due to the high concentration of s1 casein (Jordana et al., 1991). This excellent productive performance is matched by the rusticity of the breed and its ability to adapt to a wide range of climate conditions (Capote et al., 1998). Traditionally, in the Mediterranean and Canary Island regions, kid goats are reared with their dams. This practice results in a decreased milk yield from the dams available for cheese manufacturing (López, 1990). Therefore, goatkeepers remove the kids from their dams very early postnatally (15 days-of-age, 5–6 kg live weight) and these kids are then harvested for their available meat. The carcasses from these kids are very light in weight (3 kg).

With the desire for leaner meat by consumers, goat meat is attractive compared with other types of red meat (Potchoiba et al., 1990). Development of subcutaneous fat is slow in goats (Warmington and Kirton, 1990), which is why they produce carcasses that are very lean, compared with sheep of similar ages (Colomer-Rocher et al., 1992).

Age has an influence on palatability, with the meat from older goats regarded as being juicier (Smith et al., 1978). Studies on chemical composition and meat quality have suggested that goat meat is not inferior to lamb, however, goat meat is darker red in colour than lambs (Babiker et al., 1990).

There is little published information relating to the potential of increased weight at slaughter in dairy goat kids to maximize meat production. The objective of the present study was to evaluate effects on carcass quality and meat quality factors of artificial rearing of newborn kids raised on milk replacer to different end point slaughter weights of 6, 10 or 25 kg.

2. Materials and methods

2.1. Location of the study, animals and rearing

The study was conducted at the University of Las Palmas de Gran Canaria, Canary Island, Spain, approximately 400 km from Morocco West Coast. Forty-five Canary Caprine Group genotype twin male kids were used in the study. Kids were randomly assigned to three different groups, with slaughter at live weights of 6, 10 or 25 kg. Kids were fed colostrum during the first 2 days of life. After that, milk replacer (Table 1) was fed alone until 15 days-of-age, and with ad libitum access to starting concentrate pellets based on corn, soy 66 (crude protein 66%), dehydrated milk, dehydrate lucerne, wheat straw and vit-mineral corrector (Chemical composition in Table 1) and hay thereafter. Animals were weaned when they reached 10 kg of live weight. The 25 kg LWS kids after weaning were raised indoors and feed according to INRA (Jarrige, 1990) with growth concentrate pellets based on corn, soy 66, dehydrate lucerne, dehydrate beetroot, wheat straw, and vit-mineral corrector, and ad libitum access to hay. Kids were weighed every fortnight.

2.2. Slaughtering

Kids were weighed after fasting for 12 h with free access to water. The dressed carcass comprised the body after removing the skin, head (at the occipito–atlantal joint), fore feet (at the carpal–metacarpal joint), hind feet (at the tarsal–metatarsal joint) and the viscera. Kidneys, kidney and pelvic fat were retained in carcass, and testes and scrotal fat were also removed (according Colomer-Rocher et al.,

Table 1
Chemical analysis of feedstuffs offered to the kids during the experimental period

	Composition, dry matter basis (%)		
	Milk replacer	Starting concentrate	Growth concentrate
Dry matter	95.5	87.5	88.4
Ash	8.0	7.6	6.2
Crude protein	23.6	16.4	19.6
Crude fiber	0.1	4.5	4.3
Ether extract	22.7	2.5	2.1

1987). Hot carcass weight and weights of the head, skin and some visceral organs (heart, liver, lungs plus trachea, kidney, spleen) were recorded. The gastro-intestinal tract was also weighed full and after it was emptied. The results were expressed as percentage of live weight at slaughter. Empty body weight (EBW) was calculated by deducting the weight of digesta. Dressing percentage was calculated based on full live weight and EBW.

2.3. Carcass characteristics

After chilling the carcasses for 24 h at 4 °C, cold carcass weight was recorded. Carcass measurements included, fore feet length: from the symphysis pubis to the carpal–metacarpal joint; carcass length: from the symphysis pubis to the anterior edge of the middle of the first rib; and diameters: between femur trochanters and maximum width between ribs. The carcass compactness index was calculated based in cold carcass weight and carcass length measure (Thwaites et al., 1964).

2.4. Carcass dissection

After chilling, the carcasses were split down the dorsal midline. The left side was divided into five primal cuts (neck, flank, ribs, shoulder and long leg) and three minor cuts (kidney, kidney fat and tail) as described by Colomer-Rocher et al. (1987). After weighing, each cut was separated into dissectible muscle, bone and fat, with the subcutaneous and intermuscular fat depots being recorded separately. The results were expressed as percentage of side weight. According to Colomer-Rocher et al. (1987), primal cuts were grouped into three categories: extra (long leg and ribs), first (shoulder) and second (neck and flanks).

2.5. Meat quality attributes

The measures were performed on the right carcass side. Muscle pH was determined using a Crisson 507 pH meter with a combined electrode, by insertion into the longissimus (at the 12/13th rib site), semimembranosus (central portion) and triceps brachii (central portion) muscle, immediately after slaughter and after chilling (24 h). Muscle color was measured at the same sites, using a Minolta CR200 Chroma-meter (where L^* depicts relative lightness, a^* indicates relative redness and b^* represents relative yellowness). Hue and croma were calculated using a^* and b^* values according to Wyszecki and Stiles (1982). The color was recorded 24 h after slaughter. After that, mentioned muscles were excised. Water holding capacity was performance according Grau and Hamm (1953) modified by Sierra (1973). Cooked muscle cores with a cross section of 1×1 cm and at least 3 cm long were cut parallel to the muscle fibers and shear force values were taken using a Warner–Bratzler shear force apparatus on a INSTRON Machine. Proximate analysis was performed. Moisture was determined by air drying (AOAC, 1984; procedure 24.003) and fat by soxhlet extraction using petroleum ether (AOAC, 1984; procedure 13.032) The kjeldahl procedure (AOAC, 1984; procedure 2.057) was used for nitrogen determination; the conversion factor of 6.25 was used to convert nitrogen to percentage protein. The determination of ash was done according to AOAC (1984); procedure 14.066), and collagen content and solubility were determined according to procedures of Bonnet and Kopp (1984) and Hill (1966). Muscle fiber population were determined according to the Brook and Kaiser (1970) histochemistry techniques.

2.6. Statistical analysis

For carcass and meat quality variables, effects of LWS were analyzed using the ANOVA procedure (SPSS V. 8.0 programme), with birth weight as a covariate. Correlation coefficients were computed between measures.

3. Results and discussion

3.1. Growth

Six (33.72-days-old), 10 (44.70-days-old) and 25 (153.50-days-old) kg LWS kids daily gains were 99.77, 151.41 and 125.81 g/day, found statistical differences ($P < 0.008$) between them. Six and 10 LWS kids daily gains were in agreement with previous results in the same breed (Argüello, 2000) and in Verata breed (Rodríguez, 1989). Probably the different daily gain between these two groups were a better ability to drink milk replacer in 10 kg LWS kids and a higher intake capacity. LWS (25 kg) kids daily gain results were according to Hadjipanayiotou et al. (1991) in Damascus kids slaughtered at similar weight.

3.2. Dressing percentage

Dressing percentage 1 (based on full live weight) was in the range of 40–47% and was lowest among treatments for 25 kg LWS (Table 2). In contrast to dressing percentage 1, dressing percentage 2 (based on EBW) was lower for 6 vs. 10 kg LWS, with the mean for 25 kg LWS similar to those for 6 and 10 kg LWS. One of the reasons for disparate treatment differences in dressing percentages 1 and 2 was differences in the weight of gastro-intestinal tract contents as a percentage of LWS (Table 3). Six and 10 LWS did not yet have fully developed digestive tract, whereas 25 kg LWS kids had more developed tracts with more than twice the gastro-intestinal tract contents of other LWS. Similar differences were reported by Sanz et al. (1987). DP2 of kids ranged from 50 to 53%, which is in agreement with the results of López, 1990) and Potchoiba et al. (1990). Chilling losses noted in the present study were similar to previous results of López (1990).

3.3. Offal percentages

There were significant differences among LWS for all offal component tested (Table 3). For 25 kg LWS kids, percentage contributions to LWS of skin, liver, spleen, kidney, lung + trachea and heart were significantly lower than for 6 and 10 kg LWS kids. Also, percentage contributions to LWS of the full gastro-intestinal tract, empty gastro-intestinal tract,

Table 2
Dressing percentage

	Live weight at slaughter		
	6 kg	10 kg	25 kg
Fasted live weight (kg)	6.14±.32	10.04±.42	23.48±.25
Hot carcass weight (kg)	2.93±.18[a]	4.91±.12[b]	9.81±.32[c]
Cold carcass weight (kg)	2.83±.19[a]	4.74±.12[b]	9.57±.28[c]
Dressing percentage 1 (%)	46.03±2.81[a]	47.23±1.87[a]	40.77±1.75[b]
Dressing percentage 2 (%)	50.34±1.75[a]	52.90±1.03[b]	51.33±2.11[ab]
Chilling looses (%)	3.60±.73[a]	3.54±.85[a]	2.41±.31[b]

Results expressed in mean±S.D., $n = 45$; data shown in the same row with a different letter denotes a significant difference ($P < 0.001$). Dressing percentage 1 was calculated based on full live weight. Dressing percentage 2 was calculated based on empty body weight.

Table 3
Offal percentages (% on live weight at slaughter)

	Live weight at slaughter		
	6 kg	10 kg	25 kg
Skin	10.08±0.30[a]	9.78±0.56[a]	8.10±0.53[b]
Full gastro-intestinal tract	14.02±3.23[a]	16.64±2.67[a]	30.63±2.38[b]
Empty gastro-intestinal tract	8.82±0.71[a]	9.17±0.83[a]	12.06±1.37[b]
Gastro-intestinal tract content	5.20±3.13[a]	7.47±2.08[a]	18.56±2.96[b]
Liver	2.80±0.25[a]	2.65±0.28[a]	2.21±0.20[b]
Testis	0.24±0.04[a]	0.28±0.04[a]	0.47±0.07[b]
Spleen	0.21±0.03[a]	0.21±0.02[a]	0.16±0.02[b]
Kidney	0.43±0.12[a]	0.44±0.14[a]	0.18±0.01[b]
Head	9.61±0.94[a]	8.12±0.39[b]	5.88±0.82[c]
Lung + trachea	1.73±0.23[a]	1.67±0.19[a]	1.11±0.04[b]
Heart	0.70±0.07[a]	0.67±0.11[a]	0.44±0.11[b]

Results expressed in mean±S.D., $n = 45$; data shown in the same row with a different letter denotes a significant difference ($P < 0.001$).

gastro-intestinal tract contents and testis were significantly higher for 25 kg LWS vs. 6 and 10 kg. The percentage contribution of the head to LWS significantly decreased as LWS increased. Percentage contributions of various visceral organs, the head and skin reported in the present study were similar to those reported for different breeds at similar live weights (López, 1990; Johnson et al., 1995). Decreases in percentages of head and skin with increasing age reported in the present study, were previously observed by Manfredini et al. (1988) and López (1990).

3.4. Carcass measurements

There were significant differences in long leg length, carcass length, diameter between trochanters and maximum width between ribs, among 6, 10 and 25 kg LWS kids (Table 4), in agreement with results of Borghese et al. (1990). In dairy goat breeds as the carcasses are heavier, the width measures grow faster than length measures, thus the carcass compactness index is improved.

3.5. Carcass dissection

There were no significant differences among LWS in percentage contributions of tail (0.38 –0.46%), shoulder (20.4–21.1%), long leg (33.6– 33.9%), flanks (9.4–11.2%) and ribs (21.0–23.4%) to carcass side weight (Table 5). In opposition to that, kidney, kidney fat and neck percentage contributions to carcass side weight were significantly lowest among LWS for 25 kg. At similar carcass weights, the proportions of the weights of the primal cuts expressed as a percentage of side weight agree with those reported by López (1990) with the same breed and by Colomer-Rocher et al. (1992) with New Zealand Saanen goats. There were no significant differences among LWS for the percentage contribution of subcutaneous fat (3.4–5.2%), total fat (8.1–10.4%), bone (28.1–31.5%) and muscle (55.5–58.7%) to carcass side weight (Table 6). Dairy breeds of goats tend to store more fat as visceral, rather than as carcass adipose tissue (Gibb et al., 1993), which explains the low values present in subcutaneous fat. LWS (25 kg) kids deposited significantly more intermuscular fat than 6 kg LWS kids. Fat carcass proportions in the present experiment are in agreement with results of Treacher et al. (1987) and Warmington and Kirton (1990) with different goat breeds. Higher subcutaneous fat (Table 6) in 25 kg LWS, was one of the reasons for lower chilling losses in 25 kg LWS kids (Table 2), in agreement with Kirton (1988). The contribution of bone to side carcass weight tends to be lower when LWS of kids was high. Bone deposition in animal development precedes deposition of muscle and fat,

Table 5
Percentage contribution of different cuts to the carcass

	Live weight at slaughter		
(%)	6 kg	10 kg	25 kg
Kidney	1.52±0.14[a]	1.37±0.28[a]	0.88±0.05[b]
Kidney fat	2.27±0.73[a]	2.97±0.56[a]	2.01±0.92[b]
Tail	0.40±0.15	0.38±0.07	0.46±0.05
Shoulder	21.08±1.57	20.44±1.03	20.93±1.54
Neck	11.09±1.67[a]	10.50±1.43[a]	8.13±1.05[b]
Long leg	33.81±2.49	33.92±2.50	33.56±1.49
Flanks	9.66±0.77	9.42±1.83	11.16±1.09
Ribs	21.61±2.24	21.05±1.84	23.39±2.85
Extra category	55.42±3.97	54.97±2.28	56.95±1.66
Second category	20.75±1.59	19.92±2.07	19.29±1.54

Results expressed in mean±S.D., $n = 45$; data shown in the row with a different letter denotes a significant difference ($P < 0.001$).

Table 4
Carcass measurements

	Live weight at slaughter		
	6 kg	10 kg	25 kg
Long leg length (cm)	22.10±0.75[a]	24.21±0.66[b]	30.55±1.41[c]
Carcass length (cm)	37.59±3.96[a]	43.34±1.00[b]	62.98±5.49[c]
Diameter between trochanters (cm)	9.27±0.68[a]	11.17±1.15[b]	13.30±2.30[c]
Maximum width between ribs (cm)	15.70±1.58[a]	17.92±1.84[b]	23.13±0.25[c]
Carcass compactness index	76.28±13.01[a]	109.44±3.46[b]	152.91±14.26[c]

Results expressed in mean±S.D., $n = 45$; data shown in the same row with a different letter denotes a significant difference ($P < 0.001$).

Table 6
Tissue carcass distribution

(%)	Live weight at slaughter		
	6 kg	10 kg	25 kg
Subcutaneous fat	3.45±1.39	4.13±0.81	5.19±2.12
Intermuscular fat	2.33±0.71[a]	2.78±0.70[ab]	3.18±0.86[b]
Total fat	8.05±2.35	9.88±1.37	10.39±3.30
Bone	31.47±2.88	29.17±2.26	28.11±1.80
Muscle	55.92±4.06	55.49±1.83	58.66±3.34
Muscle/bone ratio	1.79±0.20[a]	1.91±0.17[ab]	2.09±0.18[b]

Results expressed in mean±S.D., $n = 45$; data shown in the same row with a different letter denotes a significant difference ($P < 0.001$).

which should be the reason for these bone results (Treacher et al., 1987). Percentages of bone in the carcass observed in the present study were slightly greater than found for other dairy goat breeds like Saanen (Warmington and Kirton, 1990), but agree with those reported by López (1990) for the same breed but with different rearing techniques. LWS (25 kg) kids tended to have a higher muscle content than 6 or 10 kg LWS kids, which contrasts the findings of Treacher et al. (1987) and Sanz et al. (1990) involving a lower muscle carcass content in weaned kids. Aggressive weaned management and post-weaning nutrition may be the reasons for these differences. López (1990) reported a similar muscle side carcass content with comparable LWS and rearing techniques. The muscle bone ratio differed between 6 and 25 kg LWS kids. Morand-Fehr et al. (1985) did not find a similar difference in Alpine and Saanen kids slaughtered at 15 and 22 kg LWS. The muscle/bone ratio of 2.09 in 25 kg LWS kids of the present experiment differed considerably from meat goat breeds like Boer with muscle/bone ratios around 3.0 (Birkammer, 1986).

Table 7 shows the principal correlation between slaughter and tissue carcass distribution. Carcass with high CCI present more subcutaneous fat and subsequently more total fat, lower bone content and better muscle/bone ratio.

Table 7
Pearson correlation values between slaughter, and carcass tissue distribution

	Correlation coefficient			
	LWS	DP1	DP2	CCI
Subcutaneous fat	ns	ns	ns	0.534**
Intermuscular fat	ns	ns	ns	ns
Total fat	ns	ns	ns	0.546**
Bone	− 0.425*	ns	ns	− 0.570**
Muscle	ns	ns	ns	ns
Muscle/bone ratio	0.526**	ns	ns	0.578**

Significance level: $**P < 0.01$; $*P < 0.05$; ns, not significant. LWS, live weight at slaughter; DP1, dressing percentage 1; DP2: dressing percentage 2; CCI, carcass compactness index.

3.6. Meat quality

The initial pH of three tested muscles ranged from 6.20 to 6.54 with minor differences among LWS (Tables 8–10). The ultimate (24 h) pH of longissimus muscle for 25 kg LWS kids was significantly lower than for 6 kg LWS kids, although there were no differences in pH in triceps brachii (5.7–5.8) or semimembranosus (5.5–5.6). The ultimate pH range is acceptable in agreement with Hedrick et al. (1994), but lower than showed by Feidt and Bellut (1996) in Alpine kids slaughtered at 24 kg. The LWS difference in ultimate pH in longissimus muscle agrees with the findings of González et al. (1983).

Lightness ($L*$) for all three muscles was lowest among LWS for 25 kg. Chiofalo et al. (1983) and Argüello et al. (1999) reported similar results. A close relation between pH and $L*$ reduction is the reason for these results. Muscle color is very important in production of Capretto carcasses where it should be pale or pink. In the present study there were no statistical differences between 6 and 10 kg LWS kids for $L*$ values. The croma value of the triceps brachii muscle for 25 kg LWS kids was greater than 6 and 10 kg LWS kids. The hue value of all muscles tested for 25 kg LWS kids was lower than for 6 and 10 kg LWS. An inverse correlation

Table 8
Longissimus meat quality characteristics

	Live weight at slaughter		
	6 kg	10 kg	25 kg
pH 0	6.30±0.31	6.20±0.36	6.47±0.11
pH 24	5.73±0.09[a]	5.59±0.15[ab]	5.54±0.17[b]
L 24	56.93±3.96[a]	52.05±4.43[a]	45.92±1.95[b]
Croma 24	16.12±5.69	16.25±6.45	20.70±1.97
Hue 24	42.08±6.09[a]	37.78±9.96[a]	25.72±3.49[b]
Shear force (N)	55.71±13.42[a]	57.16±14.10[a]	80.99±4.78[b]
WHC (g)	0.46±0.10[a]	0.47±0.15[a]	0.69±0.10[b]
Moisture (%)	78.40±1.21	77.24±0.45	76.30±1.59
Protein (%)	19.05±1.74	19.59±0.91	20.75±0.56
Muscle fat (%)	0.96±0.45	1.64±1.12	0.88±0.78
Ash (%)	1.12±0.06	1.16±0.08	1.08±0.05
Collagen (%)	0.46±0.16	0.39±0.10	0.52±0.20
Collagen solubility (%)	85.62±15.85	78.36±9.45	87.39±7.07
Muscle fiber Type I (%)	36.55±26.31	27.40±7.86	22.74±1.68
Muscle fiber Type IIA (%)	28.00±5.60	37.67±2.03	24.73±6.70
Muscle fiber Type IIB (%)	35.44±21.67	36.91±7.35	52.52±6.18
Muscle fiber area I (μ^2)	418.57±133.33	540.94±153.65	541.13±241.05
Muscle fiber area IIA (μ^2)	370.88±67.47	497.00±60.28	475.43±105.78
Muscle fiber area IIB (μ^2)	400.27±68.34	544.93±132.13	443.85±135.03

Results expressed in mean±S.D., $n = 45$; data shown in the same row with a different letter denotes a significant difference ($P < 0.001$). WHC, water holding capacity.

Table 9
Triceps brachii meat quality characteristics

	Live weight at slaughter		
	6 kg	10 kg	25 kg
pH 0	6.54±0.27	6.52±0.18	6.50±0.21
pH 24	5.80±0.14	5.75±0.08	5.69±0.10
L 24	55.47±4.98[a]	55.24±5.48[a]	45.37±1.26[b]
Croma 24	15.26±1.76[a]	16.21±2.71[ab]	19.56±2.48[b]
Hue 24	38.29±10.36[a]	40.56±9.03[a]	24.60±4.17[b]
Shear force (N)	88.40±6.85	90.79±7.48	91.27±11.71
WHC (g)	0.33±0.08[a]	0.31±0.06[a]	0.49±0.08[b]
Moisture (%)	78.47±0.45	78.55±0.40	77.78±0.79
Protein (%)	18.90±0.45	18.53±0.69	19.84±1.25
Muscle fat (%)	1.08±0.51	1.12±0.45	0.94±0.38
Ash (%)	1.16±0.07	1.11±0.06	1.09±0.07
Collagen (%)	0.40±0.06	0.53±0.06[b]	0.34±0.03
Collagen solubility (%)	83.90±12.14	74.70±10.53	92.88±11.58
Muscle fiber Type I (%)	18.70±15.32	25.34±4.10	27.08±2.94
Muscle fiber Type IIA (%)	29.58±17.16	21.93±10.35	16.52±3.15
Muscle fiber Type IIB (%)	51.70±4.82	52.63±13.22	56.25±2.58
Muscle fiber area I (μ^2)	588.19±66.51	889.35±240.18	1353.46±317.13
Muscle fiber area IIA (μ^2)	665.25±153.55	813.38±143.28	1243.56±276.86
Muscle fiber area IIB (μ^2)	676.81±48.73	910.61±192.40	1336.23±177.68

Results expressed in mean±S.D., $n = 45$; data shown in the same row with a different letter denotes a significant difference ($P < 0.001$). WHC, water holding capacity.

Table 10
Semimembranosus meat quality characteristics

	Live weight at slaughter		
	6 kg	10 kg	25 kg
pH 0	6.39±0.22	6.41±0.33	6.41±0.12
pH 24	5.64±0.80	5.62±0.07	5.49±0.06
L 24	54.49±2.11[a]	55.54±4.80[a]	44.18±2.19[b]
Croma 24	14.46±3.64	16.47±4.77	17.82±2.43
Hue 24	41.28±6.62[a]	41.56±7.29[a]	24.37±6.01[b]
Shear force (N)	43.67±6.24[a]	56.35±12.66[ab]	68.42±12.14[b]
WHC (g)	0.60±0.15	0.60±0.16	0.60±0.14
Moisture (%)	78.51±0.88	78.26±1.32	77.21±0.86
Protein (%)	18.10±1.65	18.52±1.84	20.09±1.11
Muscle fat (%)	1.10±0.51	1.20±0.47	1.27±0.78
Ash (%)	1.18±0.09	1.11±0.08	1.08±0.05
Collagen (%)	0.42±0.09	0.40±0.07	0.45±0.07
Collagen solubility (%)	74.70±8.77	77.37±11.18	61.79±27.84
Muscle fiber Type I (%)	31.40±25.65	20.31±4.17	26.17±3.98
Muscle fiber Type IIA (%)	13.82±7.59	23.13±5.27	30.26±6.22
Muscle fiber Type IIB (%)	54.77±34.62	63.36±31.96	43.55±13.34
Muscle fiber area I (μ^2)	528.04±106.57	598.74±59.53	912.73±241.43
Muscle fiber area IIA (μ^2)	598.64±114.25	782.64±168.26	1090.76±198.57
Muscle fiber area IIB (μ^2)	586.34±129.95	664.18± 150.99	866.77±132.31

Results expressed in mean±S.D., $n = 45$; data shown in the same row with a different letter denotes a significant difference ($P < 0.001$). WHC, water holding capacity.

between lightness–hue and myoglobin content was reported by Dhanda et al. (1999).

Shear force of longissimus was greatest for 25 kg LWS. Shear force of triceps brachii was similar among LWS, and of semimembranosus was greater for 25 vs. 6 kg. Shear force values were in the range of 43.7 to 91.3 N. These shear force values were high compared to 58.8 N observed in the adult Florida native goat and its crosses with Nubian and Spanish breeds (Johnson et al., 1995) and similar to 83.4 as reported by Riley et al. (1989) in Angora and Spanish breeds of goats. This variation might be due to differences in post-mortem carcass treatment, age, live weight and the types of muscles used by these workers. A decrease in tenderness with age in goats has been reported (Warmington and Kirton, 1990). This decrease appears associated with decreased collagen solubility in beef cattle (Cross et al., 1973). But, in the present study LWS did not impact. This variation might be due to differences in muscle fiber area as reported by Crouse et al. (1991).

The WHC values ranged from 0.3 to 0.7 expelled grams. These results are slightly lower than observed by Sañudo et al. (1995) in adult Spanish goat, but close to values seen by Argüello et al. (1999) in Canary Caprine Group kids. A decrease in WHC with increasing age of lambs has been noted (López, 1987), although there have been no effects of age observed as well by Solomon et al. (1980). In the present experiment, lower WHC for 25 kg LWS vs. 6 and 10 kg LWS for longissimus and triceps brachii might be due to higher ultimate pH values. LWS did not affect the moisture, protein, intramuscular fat, ash, collagen content or collagen solubility of uncooked composite goat samples (Tables 8, 9 and 10). Moisture ranged from 77.2 to 78.5%, protein from 18.1 to 20.7%, intramuscular fat from 0.9 to 1.3%, ash from 1.1 to 1.2%, collagen from 0.4 to 0.5% and collagen solubility from 61.8 to 92.9%. Moisture percentages reported by Babiker et al. (1990) and Johnson et al. (1995) for goats slaughtered at higher weights were lower than observed in the present study, due to during the animal growth the protein and fat percent increased, reducing moisture muscle content. Protein and ash percentages in the present study were similar to reports of Kesava et al. (1984) for goat kid meat. The intramuscular fat contents found in kids slaughtered at 6, 10 and 25 kg were similar to cited by Kesava et al. (1984) for Black Bengal kids slaughtered at 18 kg. Results of the present experiment were slightly lower than reported by Johnson et al. (1995) for a Florida goat breed slaughtered at 20 kg LWS, but were lower than reported by Babiker et al. (1990) in different breed slaughter at higher LWS. Collagen levels in muscles in the present study were similar to the findings of Van Niekerk and Casey (1988) in Boer goats. Values of collagen solubility were higher than those found by Van Niekerk and Casey (1988) in Boer goats or Morbidini et al. (1999) in lamb. Different ages should be the reason for these collagen solubility results, as reported by Cross et al. (1973).

LWS class did not affect muscle fiber proportions and areas (Tables 8–10). The muscle fiber interconversion had been described by Swatland (1975), but in the first stages of mammal life, it is affected by several factors. The results found in the present study are in agreement with Argüello et al. (2001). In reference to muscle fiber areas, LWS class did not affect it. A non-statistic significant tendency can be seen in Tables 8–10, when the LWS is high, in agreement with results shown by Swatland (1975).

4. Conclusion

Results suggest that increasing LWT from 6 to 10 and 25 kg for kids artificially reared does not have negative effects on carcass or meat quality but would result in more edible meat (pounds) to be marketed.

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