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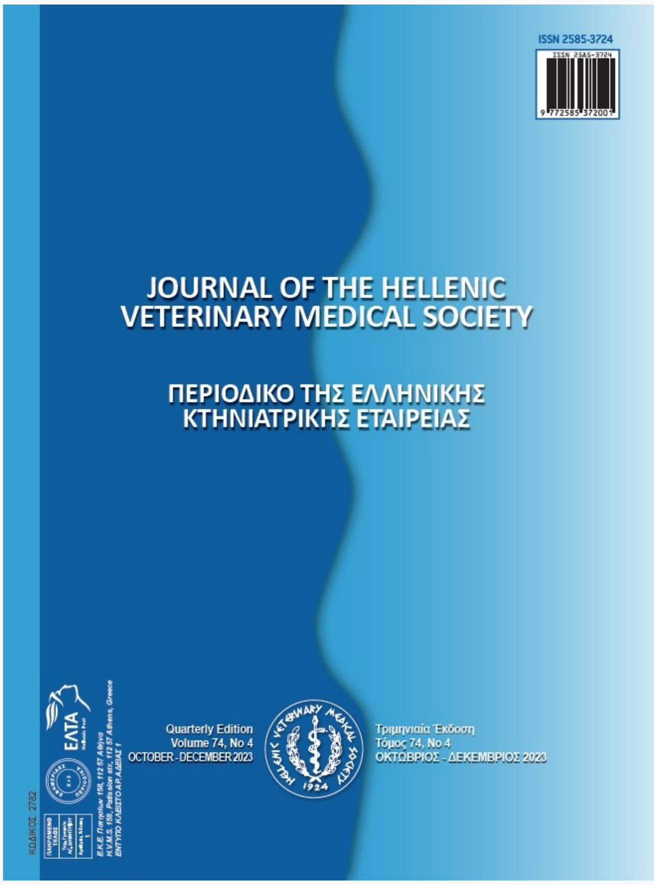

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Effect of crossbreeding with Romanov breeds on fattening performance, slaughter and carcass characteristics and meat quality of Awassi ram lambs

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ABSTRACT: The aim of this study was to examine the fattening performance, slaughter and carcass characteristics and meat quality traits of Awassi and Romanov x Awassi (ROA) (F1) ram lambs. Twenty-eight-ram lambs were allocated into two groups according to their genotype, and were fattened for 84 days. Initial and final body weights were 26.57 kg and 45.75 kg for Awassi ram lambs, 25.89 kg and 36.75 kg for ROA (F1) ram lambs, respectively. The initial body weight and feed efficiency were similar while the final body weight and daily weight gain differed between the two genotypes being greater for the Awassi. At the ends of study, 8 lambs from each genotype were randomly selected and slaughtered to evaluate the carcass and meat quality characteristics. Slaughter weight, hot and cold carcass weights were 42.07 kg, 19.50 kg and 19.01 kg for Awassi ram lambs, 33.03 kg, 15.25 kg and 14.85 kg for ROA (F1) ram lambs. The slaughter traits were significantly affected by the genotype and the highest weights were also recorded for Awassi genotype. Dressing percentages were not affected by genotype. Awassi had higher eye muscle area and fat tail percentage compared with ROA genotype. Moreover, meat quality traits were not affected by the lamb's genotype. Although lower fat tail weight was obtained from ROA (F1) crossbred lambs, it is clearly understood from the available data that pure Awassi lambs were superior to ROA (F1) crossbreeds in terms of economically important characteristics such as final weight, daily weight gain, slaughter weight and some carcass traits.

***Keywords*:** Awassi; Romanov; fattening performance; carcass characteristics; meat quality

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INTRODUCTION

The livestock sector plays an important role in Turkey and sheep breeding has an important place in animal production, therefore in agricultural production and in the country's economy (Esenbuga et al., 2009). Generally, red meat consumption refers predominantly to cattle, sheep, and goats due to economic, cultural, and religious reasons. Sheep meat is highly appreciated by the Turkish consumer, and it accounts for approximately 19.8 % of the total red meat production in Turkey (Anonymous, 2021). There are many sheep breeds adapted to different regions due to the differences in the geographical structure of Turkey. An important part of sheep breeds in Turkey consists of fat-tailed breeds. The fat tail is considered an adaptive response of animals to difficult climatic conditions and is a valuable reserve for the animal in case of migration and during harsh seasonal fluctuations. Sheep stores nutrients in their tail when food is plentiful and survive by using the storage in their tail when food is scarce (Kashan et al., 2005; Abdullah et al., 2011; Obeidat and Obeidat, 2022). Tail size shows significant variation between breeds. Fat accumulating in the body or tail results in a much higher cost in terms of feed energy than lean meat. The increasing demand for lean meat in the world has also affected consumers' choices. For this reason, breeders are working to reduce the size of the fat tail (Marai and Bahgat, 2003). Therefore, removing or reducing the fat tail of local sheep could be important for the country's sheep industry. Studies to reduce this fat tail have often been conducted by crossbreeding with thin-tailed breeds (Abdullah et al., 2003; Shaker et al., 2002; Abdullah et al., 2011; Turkyilmaz and Esenbuga, 2019). Awassi is a fat-tailed sheep bred in Turkey and the Middle East (Jordan, Iraq, Lebanon, Palestine, and Turkiye). The Awassi is raised for meat, milk, and wool production. Romanov is a sheep breed that has adapted to cold climate conditions and is known for its superior reproductive characteristics (Esenbuga et al., 2009). Romanov has been used in cross-breeding activities to increase the fertility characteristics of native breeds because it is a polyestrous breed which often has great litter size (Turkyilmaz and Esenbuga, 2019). Abdullah et al. (2011) reported that the fat tail constituted 10% of the carcass weight in Awassi ram lambs slaughtered at 40 kg of body weight. However, this percentage decreased in Romanov×Awassi (F1) and Charollais×Awassi (F1) crosses (Abdullah et al., 2003). It is important to evaluate the potentials of these crosses to increase the yield characteristics of genetic resources in terms of fattening performance, carcass characteristics and meat quality. The aim of this study is to compare the fattening performance, slaughter and carcass traits and some meat quality characteristics of Awassi purebred lambs and Romanov x Awassi (F1) crossbred lambs.

MATERIAL AND METHODS

Animals and experimental design

All processes used in this study were approved by the Animal Ethics Committee of Ataturk University (ID:2018/64). The experiment was carried out at the Food and Livestock Application and Research Center, Atatürk University, Erzurum (39°55′N, 41°17′E and 1820 m above sea level), Turkey. A total 28 males (16 purebred fat-tailed Awassi lambs and 12 Romanov x Awassi (ROA) crossbreed (50% Romanov x 50% Awassi)) lambs were used in this study. The age of the Awassi and ROA (F1) at the beginning of the fattening period was 216 and 224 days, respectively. After a two-week adaptation period, the lambs were weighed and subjected to intensive feeding by forming two completely randomized groups according to their genotypes. The lambs were penned in groups with at least 2.5 square meters of area per lamb. During the experiment, the lambs were weighed at 14-day intervals and the amount of feed provided to the lambs was determined according to the live weights obtained (NRC, 1985). The diet (consisting of a concentrated mixture) was formulated to meet the nutrient requirements of the ram lambs and was offered *ad libitum* to both genotypes during the 84-day fattening period and 300 g of hay per lamb per day was offered as well. The concentrate mixture had 89% dry matter, 12.5% crude protein, 10% crude fiber, 7.5% crude fat, and 2780 Kcal ME/kg. The grass hay had 91% dry matter (DM), 27.24% crude fiber (CF), 6.35% crude protein (CP), 2.65% ether extract (EE), and 9.10% ash (A). CP, DM, A, and EE of grass hay and concentrates were determined by standard methods of AOAC (2007). Feeding and management practices were applied equally to all lambs.

Sample collection

Body weight and feed intake of lambs were measured every two weeks. To calculate feed intake, rejected feed was collected and calculated by subtracting rejected feed from feed consumed divided by the number of animals and days. The daily weight gain was determined by finding the difference between initial bodyweight and final body weight and dividing it by the feeding days. Following the 84-day fattening period, the lambs were fasted for 12 hours and weighed repeatedly to determine their slaughter weight. Awassi (n=8) and ROA (F1) (n=8) ram lambs from each genotype were randomly selected, the body measurements were recorded and then slaughtered in a commercial abattoir. Feet, head, offal and skin were removed during slaughter, and hot carcass weights were recorded. Carcasses were kept in the cold storage at +4°C for 24 hours. Following the chilling process, carcass weights and carcass measurements were determined. In addition, pelvis fat, kidney, and kidney fat were removed and weighed separately. Fat tails were removed before the carcasses were bisected along the medial line. The 12th and 13th ribs were cut from the left side of the carcass, lateral to the vertebral column and parallel to the rib and the surface area of m. *longissimus dorsi* (LD) muscle, and fat thickness were measured. Following this, carcasses were cut into ten parts; neck, shoulder, loin, rib, sirloin, fore shank, flank, hind shank, and breast, and leg. The marbling score on the LD muscle was evaluated by two experienced assessors as small^{+} (4), small^{0} (5), and small^{-} (6). Proportional yield of the boneless retail cuts and yield grade were calculated as described by Boggs and Merkel (1993).

Yield grade = 0.4 + [10 x external fat thickness (inch)]

The lamb meat samples from *longissimus dorsi* (LD) muscles were used to determine meat quality. pH values were measured directly from the freshly cut surface of LD muscle using a direct probe of a pH meter (SCHOTT, Lab Star, USA). 24h after slaughter, color parameters were measured on LD muscle exposed to air for 30 minutes. To determine the effect of aging on color parameters, the LD muscles were maintained at 4 °C under fluorescent light for up to 12 days. Brightness (L^*), colour (a^* and b^*), hue angle (H) and chrome (C) were measured according to CIELAB (Commission Internationale I' E Clairage) using a colorimeter device (CR-200, Minolta Co, Osaka, Japan) on the LD muscle (Aurandet al., 1987; Rödel, 1992).

The meat samples were cooked in a plastic bag in a 90°C water bath until their internal temperature reached 70°C for sensory evaluation (Esenbuga et al., 2009). Cooking losses were calculated by dividing cooked weight by uncooked weight after the cooked meat samples were kept on a paper towel for 5 minutes. The cooked meat samples were sliced into samples of approximately 10 g samples and then evaluated by 10 panel members, who were tested previously and who were able to best distinguish between mutton and lamb. A panel evaluated the meat samples for juiciness, tenderness, acceptability, and flavour intensity using nine-point hedonic scale (9 = extremely juicy, 1 = extremely dry; 9 = extremely tender, 1 = extremely tough; 9 = extremely high acceptability, 1 = extremely less acceptability; 9 = intense lamb flavour, 1 = intense mutton flavour). The panel members also determined the number of chews for each sample. Meat samples were cooled to 20°C and Warner-Bratzler-Shear (WBS) device (Model 5KH29GK88, The GR Electric Mfg, USA) was used for mechanical evaluation according to the method used by Hoffman et al. (2003).

Statistical analysis

The statistical analysis was performed using the Independent-Samples *t* test procedure of SPSS software (2020) for data regarding with fattening performance, slaughter and carcass characteristics and meat quality parameters. The rest of the data was statistically analyzed using General Linear Model (GLM) procedure of SPSS, a mathematical model that included the effects of breed.

RESULTS AND DISCUSSION

Table 1 shows initial and final body weight, daily weight gain, and feed efficiency. While initial weight and feed efficiency were similar, final weights and daily weight gain were significantly different (P<0.05). Awassi lambs showed a significant increase (P<0.05) in daily weight gain and final body weight compared to ROA (F1) crossbred lambs. When pure Awassi and ROA (F1) crossbred lambs were compared in terms of body measurements, it was observed that the measurements except wither height are statistically similar. The values obtained for the fattening performance in this study were lower than the values reported by Shaker et al. (2002) for pure Awassi and ROA crossbreds. These authors reported that crossbreds had higher final weight and daily weight gain in comparison with purebred lambs. Similarly, the final weight and daily weight gain values obtained for Awassi male lambs were lower than the values reported by Tekel et al. (2007), Esenbuga et al. (2009), and Sireli and Tekel (2013). In terms of body measurements, the values reported by Shaker et al. (2002) for Awassi and ROA (F1) were also found to be higher than the values obtained in this study.

Table 1. Means (±S.E.) of fattening performance and live body measurements for Awassi and ROA (F1) ram lambs

	Awassi	ROA (F1)	*P*-Value
Fattening performance			
Initial body weight (kg)	26.57±1.63	25.89±0.83	0.191
Final body weight (kg)	45.75±1.57	36.75±0.98	0.021
Daily weight gain (kg)	0.23±0.02	0.13±0.01	0.036
Feed efficiency (kg feed kg^{-1} gain)	6.48±0.15	6.99±0.21	0.242
Live body measurements (cm)			
Body length	53.50±1.71	52.50±3.30	1.00
Rump height	64.50±1.32	61.00±1.73	0.159
Wither height	61.50±0.29	55.00±1.78	0.011
Chest depth	27.00±1.23	24.25±1.11	0.147

Slaughter weights, hot and cold carcass weights, and dressing percentages are presented in Table 2. Awassi male lambs had statistically higher values than ROA (F1) crossbreeds for slaughter weights (P<0.01), hot and cold carcass weights (P<0.05). However, dressing percentages were similar in the Awassi and ROA (F1) crossbreeds. It was observed that slaughter weights, carcass weights and dressing percentages were lower than the values reported by Shaker et al. (2002) and Abdullah et al. (2010), Abdullah et al. (2011) for the same genotypes. The results reported by Tekel et al. (2020) working with ROA (G1) crossbreeds, for slaughter weights (33.60 kg), hot carcass weights (15.69 kg), and dressing percentage (44.67%) were similar to the results obtained in this study. The most important reasons for these discrepancies may be attributed to the different initial ages and/or the different fattening times.

The results of offal weights in slaughtered ram lambs are presented in Table 2. Evaluation of carcass for offal parts showed that the genotype affected the feet and pelt weights (P<0.01). The highest feet and pelt weight was found in Awassi ram lambs. The head, testicle, and offal weights were not affected by the genotype. Similar results (for the head, testicle, and offal) were reported by Shaker et al. (2002) and Tekel et al. (2020). However, Shaker et al. (2002) reported that pelt weights were similar for Awassi and ROA (F1). Turkyilmaz and Esenbuga (2019) reported that pure Morkaraman male lambs had higher slaughter and carcass values compared to Romanov x Morkaraman(RxM) (F1) crosses in their study.

Table 2 shows data for carcass quality parameters. When compared with Awassi and ROA (F1) crossbreeds for the marbling score, fat thickness, yield

Table 2. Means (±S.E.) of slaughter characteristics for Awassi and ROA (F1) ram lambs

	Awassi	ROA (F1)	*P*-Value
Slaughter traits			
Slaughter weights (kg)	42.07±0.63	33.03±1.14	0.001
Hot carcass weights (kg)	19.50±0.91	15.25±1.11	0.040
Cold carcass weights (kg)	19.01±1.19	14.85±1.11	0.040
Hot dressing percentage (%)	46.35±0.83	46.20±1.04	0.256
Cold dressing percentage (%)	45.19±0.90	45.00±0.98	0.312
Offal parts (kg)			
Feet weights	1.09±0.44	0.75±0.27	0.001
Head weights	2.55±0.13	2.22±0.16	0.151
Testicle weights	0.31±0.02	0.26±0.03	0.295
Pelt weights	8.35±0.84	4.79±0.24	0.007
Offal weights	1.59±0.96	1.56±0.96	0.765
Carcas quality			
Marbling score[a]	4.50±0.29	4.50±0.29	1.000
LD area (cm^2)	13.57±1.63	10.58±1.07	0.042
Fat thickness (mm)	3.10±0.06	3.40±0.02	0.162
Yield grade	2.80±0.07	2.60±0.12	0.263
Retail cut (%)	45.82±0.25	46.09±0.38	0.312

[a]: Marbling scores: 4 = $small^{+}$, 5 = $small^{0}$, 6= small-.

grade, and retail cut no statistically significant differences were found. Similar results were reported by Shaker et al. (2002) in the same genotypes. The fat deposition in lean tissue requires less energy than the fat deposition in body or tail. It was observed that the fat thickness in the LD muscle was not affected by the genotypes. Although the criteria for establishing carcass yield grades differ from country to country, carcass fatness is a key factor and is usually defined by measurement of subcutaneous fat (Esenbuga et al., 2009). Yield grade is affected by carcass weight, loin-eye area, and fat thickness. The LD area is an important indicator of meat quantity and muscle development and is highly correlated with the total meat amount in the lamb carcass (Souza et al., 2013). LD area was significantly affected by genotype and Awassi had the highest LD area with comparable value ROA (F1) crossbreeds. The LD areas determined in this study were found to be higher than the value reported by Shaker et al. (2002) for pure Awassi (12.15 cm^2) ram lambs and lower than the value reported for ROA (F1) (14.44 cm^2) crossbreeds ram lambs. Abdullah et al. (2010) reported higher LD values for ROA (F1) crossbreeds.

Table 3 shows data for carcass components. When Awassi and ROA (F1) were compared in terms of carcass components, it was observed that all parameters were statistically similar except for loin, leg, and tail weight. When Awassi ram lambs were compared with ROA (F1) ram lambs, it was determined that they had higher loin, leg, and tail weights. Similar results were reported by Tekel et al. (2020) in ROA (G1) crossbreeds and Abdullah et al. (2010) in Awassi and ROA (F1) in terms of carcass components. Shaker et al. (2002) reported that pure Awassi had the lowest shoulder weight values, while Awassi × Romanov crosses had significantly higher shoulder weight. Fat tail weight was the highest for the pure Awassi lambs. While Awassi × Romanov lambs had the highest rack percentage, leg and loin percentages were the highest for Awassi × Charollais genotype lambs (Shaker et al., 2002). The decrease of the fat tail in ROA (F1) crossbreed lambs was in agreement with Shaker et al. (2002), Kashan et al. (2005), Abdullah et al. (2010), Abdullah et al. (2011), Turkyılmaz and Esenbuga (2009), and Tekel et al. (2020).

Chest circumference and leg width were significantly affected by genotype. On the contrary, carcass length, back-waist length, leg inner length, and leg depth were not affected by genotype. The highest carcass measurements were recorded for pure Awassi ram lamb. Contrary to this study, Shaker et al. (2002) and Abdullah et al. (2010) reported that ROA (F1) crossbred lambs had higher carcass measurements than Awassi ram lambs.

Table 3. Means (±S.E.) of carcass components and carcass measurements for Awassi and ROA (F1) ram lambs

	Awassi	ROA (F1)	*P*-Value
Carcass components (kg)			
Flank	0.24±0.04	0.30±0.06	0.438
Neck	0.34±0.05	0.33±0.04	0.866
Foreshank and breast	1.75±0.11	1.72±0.10	0.775
Rib	0.69±0.06	0.63±0.08	0.536
Loin	1.04±0.05	0.77±0.07	0.022
Sirloin	0.61±0.06	0.53±0.11	0.537
Leg	1.87±0.63	1.59±0.10	0.043
Hindshank	0.36±0.04	0.29±0.09	0.126
Tail weight	2.90±0.10	0.12±0.02	0.0001
Kidney (g)	95.75±3.90	92.75±6.21	0.697
Kidney fat (g)	22.25±2.84	29.25±6.79	0.379
Pelvic fat (g)	49.25±4.55	74.0±19.20	0.256
Carcass measurements (cm)			
Carcass length	65.75±1.60	62.25±1.65	0.179
Back-waist length	43.25±2.98	39.25±4.27	0.317
Leg inner length	32.00±1.47	28.75±1.11	0.128
Leg width	20.75±0.63	18.75±0.48	0.045
Leg depth	16.25±0.85	15.50±0.50	0.477
Chest circumference	37.75±0.63	34.75±0.48	0.009

Table 4. Means (±S.E.) of meat quality characteristics for Awassi and ROA (F1) ram lambs

	Awassi	ROA (F1)	*P*-Value
pH	6.06±0.11	5.96±0.08	0.476
WBS (kg/cm^2)	3.45±0.45	3.15±0.32	0.147
Cooking loss (%)	66.00±10.87	64.50±10.94	0.926
Colour parameters			
L* (lightness)	41.50±0.92	41.75±1.02	0.871
a* (redness)	14.50±0.65	16.00±0.65	0.060
b* (yellowness)	5.00±0.51	5.50±0.51	0.952
Croma	17.87±0.55	16.75±0.56	0.136
Hue angle	16.25±2.12	18.75±2.63	0.145
Sensory parameters			
Tenderness	6.83±0.21	6.98±0.45	0.775
Juiciness	5.48±0.08	5.63±0.26	0.595
Flavor	5.33±0.23	6.08±0.27	0.075
Overall acceptability	5.58±0.31	5.85±0.38	0.596
Number of chews	23.80±1.20	24.00±1.94	0.933

WBS: Warner-Bratzler shear force

Table 4 shows data for meat quality parameters measured on LD. The pH value reflects the speed of muscle glycogen degradation after slaughter. Even though Awassi had numerically higher pH, WBS, and cooking loss, the effect of genotype on these traits was found to be insignificant. Some researchers reported differences in these parameters (Esenbuga et al., 2009), while other researchers reported no significant effect of genotype (Abdullah et al., 2011; Obeidat and Obeidat, 2022). These contradictions may be the result of the differences in slaughter weight, age, diet and management practice.

Meat color is critical for the market value as it affects the presentation and acceptability of fresh meat. Color is key to ensure customer appeal and contributes strongly to the value of the product. In addition, consumers often associate food color and quality with taste, acceptability, and safety (Esenbuga et al., 2009; Farghalyet al., 2022). The color value may vary depending on the breed, geographical location, age, sex, and management condition of the animal from which the lamb meat is obtained (Esenbuga et al., 2009). As color parameters, L*, a*, b*, C and H values were examined and presented in Table 4. The effect of genotype on color parameters was found to be insignificant. Similar to the results obtained in our study, Abdullah et al. (2011) reported the effect of genotype for a*, b*, C and H values as insignificant. However, it was reported that the effect of genotype was important for L* values and Awassi male lambs had higher L* values than ROA (F1) crossbreds. It was reported by Esenbuga et al. (2009), Turkyilmaz et al. (2021), Obeidat and Obeidat (2022) and Tekerli et al. (2022) that the effect of genotype on the color parameters determined on the LD muscle was insignificant. Aging time is a process that causes meat to gain tenderness. When this process works correctly, aged meat will have improved tenderness than fresh meat. Aging time effect on color parameters was examined and it was determined that the effect of aging on color parameters was significant ($P<0.01$). Changes of color parameters according to aging time are presented in Figure 1. Abdullah et al. (2011) in their study with similar genotypes reported that the effect of aging time on a* and C values was significant, and the effect on L*, b* and H was insignificant.

The sensory characteristics of meat may vary according to breed, gender, age, feeding or post-mortem process. Sensory characteristics of the *longissimus dorsi*samples are presented in Table 4. In the sensory analysis, it was determined that there was no significant difference between Awassi and ROA (F1) ram lambs in terms of juiciness, tenderness, overall acceptability, flavour, and the number of chews (Table 4).

CONCLUSION

Awassi had greater fattening performance, slaughter and carcass characteristics than ROA (F1) crossbreds. The genotype does not have a significant effect on some meat quality and sensory characteristics of lambs. As a result, although lower fat tail weight was obtained from ROA (F1) crossbred lambs, it is clearly understood from the available data that pure Awas-

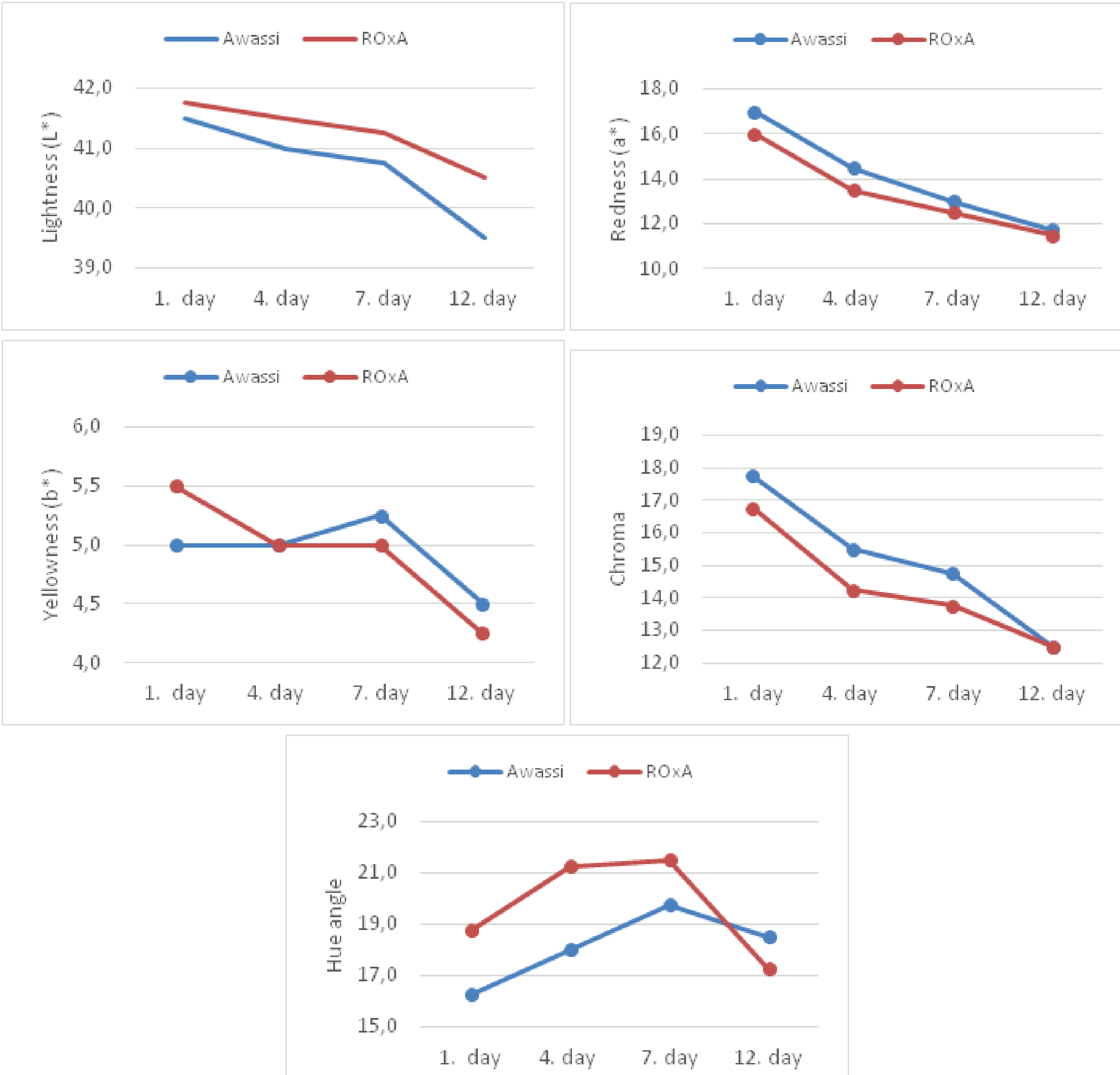

Figure 1: Color parameters (L*, a*, b*, C, and H) for Awassi and ROA (F1) ram lambs during aging periods

si lambs were superior to ROA (F1) crossbreeds in terms of economically important characteristics such as final weights, daily weight gains, slaughter weights and some carcass weights. In addition, the marbling score, yield grade, and retail cut values of the fat-tailed Awassi sheep, similar to its lean-tailed crossbreed, were also remarkable in terms of consumption, considering the high values it shows in other parameters.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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