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THE EFFECT OF DIET ON GROWTH PERFORMANCES, CARCASS AND MEAT QUALITY CHARACTERISTICS OF LAMBS FROM TSIGAI BREED

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Abstract

The aim of this study was to determine the effects of diet on growth performances, carcass and meat quality of Tsigai lambs – rusty variety fed with different diets, in order to improve meat quality and meat sensory characteristics of lambs; forty male lambs (L1 and L2, n = 20 heads/ group) were used in experiment from birth up to 5 months. No significant differences (p > 0.05) were found between the two lots with regard at final weight and average daily gain. The diet had a significant effect between L1 and L2 groups in terms of hot carcass weight and hot slaughter yield (p < 0.001), cold carcass weight and cold slaughter yield (p < 0.01), as well for commercial yield (p < 0.05). The juiciness and overall difference were strongly influenced by the diet administered in the present study, significant differences (p <0.001) being recorded between meat from the two groups. The diet administered to L1 influenced positively the eating qualities of lamb meat, resulting in a more juicy and tender meat, in which the specific lamb taste was attenuated.

Key words: *diet, lamb, meat, sensory characteristics, Tsigai.*

INTRODUCTION

The latest official numbers available in Romania show that the country's sheep population reached about 10.4 million heads (FAOSTAT, 2021), the breed structure being dominated by indigenous, unimproved breeds (Turcana and Tsigai) (Gavojdian et al., 2016).

At Turcana sheep, Gavojdian et al., (2013) reported that the weight of lambs at different age are influenced from genotype, and not from rearing system, altough housing and feeding condition of lamb are superior under semi-intensive rearing practices. The Romanian Rusty Tsigai is a native sheep bred in central Transylvania.

The total number of Tsigai has a large population size (2 500 000) (Kusza et al., 2011), but some of varieties are endangered. The Tsigai sheep had an important role (Kukovics & Kume, 2005) in the development of Turkish Kivircik populations (Marmara and Trakya) which are critically endangered bred in North-West Turkey for meat, wool and milk (Elmaci et al., 2006). Managed semi-intensively under European temperate conditions, Gavojdian et al. (2015) reported high value for litter size in Tsigai ewes, value that might be attributed to the good feeding and management condition.

The unimproved breed Tsigai is kept extensively in mountainous and sub-mountainous regions with large pasture areas. Like Turcana, Tsigai sheep is a multi-purpose breed with focus on cheese production. With regard to the potential of Tsigai breed for meat production, in recent years, the breeders believe it would be more efficient to keep the pure breed for meat than for milk production (Ilişiu et al., 2012). The breeders have considered that using crossbreeding of the foreign breeds specialized by meat production for half-breed lamb production would make the growth of the Tsigai breed more efficient (Ilișiu et al., 2013). To improve meat production at Tsigai sheep, were imported specialized breeds for meat production to improve the skills of fattening and carcass quality, namely: Suffolk, Ile de France, Merinofleisch, German Blackface. The obtained results were in all cases higher than those obtained from the Tsigai breed (Ilişiu et al., 2010), but under the potential of improved breed (for lamb). The risk of losing the pure breed Tsigai is relevant and becomes evident because many sheep herders would like to increase the genetic quality of these high performance breeds in their herds.

Taking into account the above mentioned aspects, the improvement of Tsigai sheep for meat production needs to be done in purebred through selection and adaptation of feed technologies according to the objectives pursued in the selection process.

The feeding is one of the major costs in animal production and they can affect the composition of the carcass (Lewis et al., 2002) and the degree of fattening. Despite the importance that breed and feed type have individually in determining the quality of the carcass, it is possible that the interaction between two or more factors also affects quality and characteristics of lamb carcasses (Díaz et al., 2002; Mustafa et al., 2008; Ríos-Rincón et al., 2014).

The aim of this study was to determine the growth performances, carcass and meat quality of Tsigai lambs – rusty variety fed with different diets, in order to improve meat quality and meat sensory characteristics of lambs.

MATERIALS AND METHODS

The present research was conducted in Experimental Base Reghin of Research and Development Institute for Sheep and Goat Palas - Constanta, Mures County, 46°46' N/ 22°42'E; 395 m altitude; annual rain fall varies between 650-700 mm; average temperatures 19/–3°C during summer/winter).

The growth performances of the lambs from Tsigai breed were followed from birth up to the age of 5 months. The experiment included two lots of lambs (20 heads/lot) born in January-March interval. At birth or shortly thereafter, lambs were identified with ear tags and weighed (±0.1 kg). Sex, date of birth, type of birth, dam and ram group were recorded. The lambs were also weighed monthly (±0.1 kg) up to 5 month age. Ewes and their lambs were kept together under the same management condition. Until weaning, the lambs were creep fed (*ad libitum*, 135 g DP and 10.89 MJ NE) and weaned at 66 days and 58 days, respectively. The structure of concentrated fodder was: 30% corn flour, 30% barley flour, 25% corn grain, 11.25%, sunflower groats, 2.25% calcium and 1.5% salt. After weaning, the two lots (L1, L2) of lambs were fed with different diet up to 5 months, the lambs are raised on shelter, and the diet was offer *ad libitum*. For the lot 1, the concentrate fodder was the same like in the suckling period (from birth up to end of fattening), while for the lot 2, the fattening period was divided into two phases (6 April-6 June and 7 June - 15 July) (Table 1). Additionally, for both lots, in the ration was added hill hay.

Table 1. Structure of concentrate fodder used in fattening experiment with lambs from Tsigai sheep

Characteristics	After weaning			
	6 April - 6 June		7 June - 15 July	
	L1	L2	L1	L2
Corn flour (%)	30.0	4.00	30.0	20.0
Barley flour (%)	30.0	4.00	30.0	20.0
Corn grain (%)	25.0	90.00	25.0	50.0
Sunflower groats (%)	11.25	1.50	11.25	7.5
Calcium (%)	2.25	0.30	2.25	1.5
Salt (%)	1.5	0.2	1.5	1.0
Dry matter/kg concentrated fodder	820	830	820	830
Digestible protein g/kg dry matter	135	100	135	118
NE MJ/kg dry matter	10.89	11.29	10.89	10.89

Calculated composition was derived from tabular values based on ingredient composition of the experimental diet (NRC, 2007).

At the end of the fattening, 6 Tsigai male lambs (3 from each lot) were brought to the abattoir for small and large animals from Reghin city. The lambs were subjected to a fast of 24-hour, were weighed and then slaughtered after electrical stunning. After the removal of non-carcass components, lamb carcasses were weighed and chilled at 4 ºC for 24 h and then carcass weights were recorded.

Commercial dressing percentage was calculated based on pre-slaughter live weight, while warm and cold slaughter yield was calculated based on empty body weight. Carcasses were split into two halves and the: gigot, shoulder + arm, cutlet and rest carcasses were determined. For determining of the *Longissimus dorsi* (*LD*) area, the semi-carcass was sectioned between the D12 and D13 vertebra and between 3 and 4 lumbar vertebrae, perpendicularly on the axis of the backbone, the shape of the *Longissimus dorsi* muscle being copied on transparent paper. The leg muscle section area from the half of the femur was sectioned, perpendicularly on its longitudinal axe, the shape of this section being copied on transparent paper. The size of the areas were determined on the computer.

In order to be used in meat quality analyses, *LD* muscle was removed from right side of the carcasses at 24 h post-slaughter and were packed. For sensory evaluation, meat samples were frozen and kept at –18°C until the day before the panel evaluation. Meat samples, which were served to untrained panellists, were prepared according to the methodology descry-bed by AMSA (2015). Sensory characteristics of cooked samples were assessed by 24 panellists using the degree of difference test. The panellists assessed the lambs breed difference in juiciness, tenderness, flavour, appearance, the difference of specific lamb taste and overall difference. The scale used has a seven point category (scale 1= no difference, 2 = very small difference, 3 = small difference, 4 = moderate difference, 5 = big difference, 6 = very big difference, 7 = extremely big difference).

The traits investigated were classified as lamb, carcass, and meat traits. Early growth traits consisted of birth weight (BW); weaning weight (WW), post-weaning weights at 5 months (W5M). Carcass traits included warm carcass weight (WCW), cold carcass weight (CCW), hot slaughter yield (HSY), cold slaughter yield (CSY) and commercial yield (CY). Meat sensory characteristic refers to juiciness, tenderness, flavor, appearance, the difference of specific lamb taste and overall difference. In order to determine the effect of diet on growth performance, carcass and meat quality characteristics, the mean comparisons between the two groups of the variables were carried out using independent samples Student t-test of the JASP procedure.

RESULTS AND DISCUSSIONS

The effects of fed ration on lamb growth performance are presented in Table 2. Lambs' ages in the two groups in the research were smaller with cca. 10 days at birth, weaning and at end of fattening (5 months), weaning weight and weight at the end of fattening were similar in the two lots.

The experimental plan was to test the diet starting from the same body weight. Although the two lots were fed with the same fed up to weaning, and they had the same body weight at birth and weaning, the average daily gain from birth to weaning were significantly higher in lot 2 (who is about 10 days younger than in lot 1). Post-weaning, the average daily gain was not significant between the 2 lots.

The values obtained regarding daily dry matter intake, net energy and digestible protein are given in Table 3. The data table shows that during fattening, the highest dry matter intake was recorded in L1. The evolution of specific consumption (SC) of feed throughout the fattening period has major importance in the sense that the economic efficiency of fattening is dependent on this indicator. The evolution of specific consumption (SC) of feed during fattening period are shown in Table 4.

Table 2. Means ± SE (standard errors) for birth weight, final live weight and average daily gain in lambs fed with different rations

Characteristics	L1	L2	P value
Birth weight, kg	4.44 ± 0.16	4.44 ± 0.15	1.000
Weaning weight, kg	20.16 ± 0.48	20.17 ± 0.51	0.983
Weight at final of fattening, kg	42.23 ± 1.07	40.18 ± 1.41	0.367
Total weight birth – weaning, kg	15.72 ± 0.48	15.73 ± 0.48	0.982
Total weight weaning – final of fattening, kg	22.07 ± 0.84	20.01 ± 1.31	0.982
ADG[d] birth – weaning, g	238.10 ± 7.67[a]	277.10 ± 11.06[b]	< 0.001
ADG[d] weaning – 5 months, g	225.83 ± 5.93	225.33 ± 8.80	0.963
ADG[d] birth – 5 months, g	227.19 ± 5.96	226.76 ± 8.86	0.968
Weaning age, days	66.35 ± 1.45[a]	57.90 ± 2.11[b]	< 0.001
Age at end of fattening, days	166.35 ± 1.45[a]	157.90 ± 2.11[b]	***, < 0.001
Slaughter age	166.35 ± 1.45[a]	157.90 ± 2.11[b]	< 0.001

[a,b] Means in the same line with different superscripts are significantly different. [d] ADG, average daily gain

Table 3. Daily dry matter intake (DMI), NE (net energy) and digestible protein (DP) during fattening period

Characteristics	L1	L2
DMI kg/animal	0.94	0.85
NE MJ/animal	13.06	11.83
DP g/kg animal	127.00	100.00

Table 4. Specific consumption (SC) during fattening period

Characteristics	L1	L2
NE MJ/kg gain	46.67	46.91
DP g/kg gain	583.58	506.91

Compared to the two lots, it is noticed that the highest protein consumption was recorded to the L1, while, the energy consumption was the same.

The effects of the ration on carcass quality characteristics are shown in Table 5. The diet had a significant effect on hot and cold carcass weight, and on hot, cold and commercial yield as well as on leg of muscle section area

The lambs from L1 presented higher live weight, hot and warm carcass weight, hot, warm and commercial yield and leg of mutton muscle area than L2. There were significant differences ($p < 0.001$) between L1 and L2 groups in terms of hot carcass weight and hot slaughter yield. In terms of cold carcass weight and cold slaughter yield were found significant differences ($p < 0.01$). With regard al commercial yield and leg of mutton muscle section area, were significant differences between the two lots ($p < 0.05$). The lambs from the group 1 were slaughtered at higher slaughter weight than their group 2 counterparts although all lambs were at similar starting weight in the research. These differences in final live weight might be explained by the protein and energy levels during fattening period.

Due to the very high variation of body weight at the end of fattening (36-51 kg in L1 and 26.5-55 kg in L2), for slaughter were chosen lambs with close body weights both within and between the lots. The evaluation of the carcass quality was based on the appreciation of the share of main cut sections of carcass (leg of mouton, shoulder + arm, cutlet and rest carcasses) and the share of the basic tissues that physically compose the carcass, namely the amount of muscle mass, bones and adipose tissue, the determinations being made both for the half-carcass and for the main cut portions (Table 6 and Table 7). Statistical data processing confirms the existence of significant differences ($p<0.01$) for the characters represented by the weight of the half-carcass and the amount of muscle mass in the half-carcass.

Table 5. Means ± SE for certain carcass quality characteristics of lambs fed with different diet

Characteristics	Lot 1 (n = 3)	Lot 2 (n = 3)	**T-Test**	The significance of differences
Live weight, kg	37.00 ± 0.58^a	35.33 ± 0.33^b	2,5	*, $p < 0.05$
HCW, kg	19.37 ± 0.42^a	17.22 ± 0.36^b	3.879	***, $p < 0.001$
CCW, kg	18.43 ± 0.36^a	16.73 ± 0.39^b	3.191	**, $p < 0.01$
HSY, %	52.34 ± 0.79^a	48.72 ± 0.66^b	3.536	***, $p < 0.001$
CSY, %	49.77 ± 0.25^a	47.35 ± 0.76^b	3.024	**, $p < 0.01$
CY, %	60.41 ± 0.52^a	57.68 ± 0.99^b	2.442	*, $p < 0.05$
Leg of mutton muscle section area, cm^2	112.48 ± 8.56^a	92.08 ± 1.85^b	2.326	*, $p < 0.05$
LD muscle section area at 12 ribs, cm^2	14.60 ± 0.26	14.79 ± 2.00	-0.096	ns, $p > 0.05$
LD muscle section area at 3-4 lumbar vertebrae, cm^2	13.57 ± 0.55	10.77 ± 2.34	1.916	ns, $p > 0.05$

[a,b] Means in the same line with different superscripts are significantly different

In the study performed, it was found that between the two lots, there are significant differences ($p<0.01$) for the gigot weight and for the total amount of meat in the gigot. Shoulder + arm analysed as a region of butchery cut from the carcasses, highlights the fact that in terms of percentage participation in the total weight of carcass muscle mass, in group 1 the values are higher, therefore the meat/bone ratio is higher to this lot. At the cutlet level, the determinations made on half-carcasses show that the meat/bone ratio is higher in group 2, while for the rest of the carcass, the meat/bone and meat/fat ratio is higher in group 1. Meat/bone and meat/fat ratio of 3.06 and 4.01, respectively from semi-carcass of lot 1, are superior to the semi-carcass of lot 2. The differences between the two groups (L1 and L2) in terms of lean, fat and bone percentages were probably caused by different protein and energy levels in the diet. Furthermore, increased slaughter weight causes a change in carcass composition, which ap- pears as a decrease in lean ratio and an increase in the fat ratio, especially subcutaneous fat, in the carcass (Díaz et al., 2002; Santos-Silva et al., 2002; Majdoub-Mathlouthi et al., 2013).

Table 6. Means ± SE for the main cut sections of carcass from lambs submitted to fattening

Characteristics	Lot 1 (n = 3)	Lot 2 (n = 3)	**T-Test**	The significance of differences
Live weight, kg	37.00 ± 0.58[a]	35.33 ± 0.33[b]	2.500	*, $p < 0.05$
CCW, kg	18.43 ± 0.36[a]	16.73 ± 0.39[b]	3.191	**, $p < 0.01$
Leg of mutton, kg	6.57 ± 0.20[a]	5.73 ± 0.15[b]	3.341	**, $p < 0.01$
Cutlet, kg	2.23 ± 0.03[a]	1.63 ± 0.07[b]	8.050	***, $p < 0.001$
Shoulder + arm, kg	3.13 ± 0.17	2.93 ± 0.18	0.824	ns, $p > 0.05$
Carcass rest, kg	6.50 ± 0.35	6.43 ± 0.28	0.173	ns, $p > 0.05$

[a,b] Means in the same line with different superscripts are significantly different

Table 7. Means ± SE for tissue structure of lambs fed with different diet

Characteristics	Lot 1 (n = 3)	Lot 2 (n = 3)	**T-Test**	The significance of differences
Half-carcass, kg, from wich:	9.22 ± 0.25 [a]	8.38 ± 0.19 [b]	3.344	***, $p < 0.001$
Leg of mutton, kg:	3.28 ± 0.10 [a]	2.87 ± 0.07 [b]	3.341	***, $p < 0.001$
- meat, kg	2.08 ±0.04 [a]	1.70 ± 0.10 [b]	3.507	***, $p < 0.001$
- bone, kg	0.67 ± 0.06	0.65 ± 0.03	0.250	ns, $p > 0.05$
- fat, kg	0.53 ± 0.04	0.52 ± 0.07	0.196	ns, $p > 0.05$
Meat/bone ratio	3.10	2.62	-	-
Meat/fat ratio	3.92	3.27	-	-
Cutlet, kg	1.54 ± 0.07	1.37 ± 0.06	1.858	ns, $p > 0.05$
- meat, kg	0.95 ± 0.06	0.86 ± 0.01	1.467	ns, $p > 0.05$
- bone, kg	0.38 ± 0.02	0.31 ± 0.01	1.703	ns, $p > 0.05$
- fat, kg	0.21 ± 0.02	0.20 ± 0.03	0.340	ns, $p > 0.05$
Meat/bone ratio	2.50	2.77	-	-
Meat/fat ratio	4.52	4.30	-	-
Shoulder + arm, kg:	1.57 ± 0.08	1.47 ± 0.09	0.824	ns, $p > 0.05$
- meat, kg	0.97 ± 0.03	0.90 ± 0.10	0.632	ns, $p > 0.05$
- bone, kg	0.35 ± 0.29	0.35 ± 0.08	0.000	ns, $p > 0.05$
- fat, kg	0.25 ± 0.06	0.22 ± 0.02	0.555	ns, $p > 0.05$
Meat/bone ratio	2.77	2.57	-	-
Meat/fat ratio	3.88	4.09	-	-
Carcass rest, kg:	2.83 ± 0.20	2.67 ± 0.08	0.758	ns, $p > 0.05$
- meat, kg	1.85 ± 0.13 [a]	1.46 ± 0.02 [b]	3.055	**, $p < 0.01$
- bone, kg	0.51 ± 0.08	0.54 ± 0.04	-0.324	ns, $p > 0.05$
- fat, kg	0.47 ± 0.06	0.66 ± 0.08	-1.978	ns, $p > 0.05$
Meat/bone ratio	3.63	2.70	-	-
Meat/fat ratio	3.94	2.21	-	-
Total meat, kg	5.85 ± 0.16 [a]	4.74 ± 0.17 [b]	3.734	***, $p < 0.001$
Total bone, kg	1.91 ± 0.08	1.86 ± 0.12	0.405	ns, $p > 0.05$
Total fat, kg	1.46 ± 0.11	1.60 ± 0.12	- 0.824	ns, $p > 0.05$
Total meat, %	64.84 ± 2.09	61.72 ± 1.86	0.653	ns, $p > 0.05$
Total bone, %	21.19 ± 0.27	23.27 ± 1.04	0.721	ns, $p > 0.05$
Total fat, %	16.17 ± 1.18	20.08 ± 1.71	-1.879	ns, $p > 0.05$
Meat/bone ratio	3.06	2.55	-	-
Meat/fat ratio	4.01	2.96	-	-

[a,b] Means in the same line with different superscripts are significantly different.

The effects of diets on meat sensory characteristics are presented in Table 8. The juiciness and overall difference perception of the difference between the members of the evaluation committee were strongly influenced

by the diet administered in the present study registering very significant differences ($p <0.001$) between the meat from the two groups. On a scale of 1 to 7, it is found that the juiciness has an average value of 5.21 in group 1 and 3.71 in group 2. The perception of the panelists indicated differences represented statistically ($p <0.05$) between the 2 groups regarding the tenderness and the specific lamb taste. Therefore, it can be seen that the diet administered to group 1 influenced positively the eating qualities of lamb, resulting in a more juicy and tender meat, in which the specific lamb taste was attenuated. Hopkins et al. (2006) reported that tenderness and intramuscular fat level were significant predictors of the consumer sensory traits.

Table 8. Means ± SE for meat sensory characteristics of lambs reared with in different diets

Characteristics	L1	L2	**T-Test**	The significance of differences
Juiciness	5.21 ± 0.24[a]	3.71 ± 0.27[b]	4.185	***, p < 0.001
Tenderness	4.38 ± 0.26[a]	3.58 ± 0.27	2.113	*, p < 0.05
Flavor	3.96 ± 0.34	3.58 ± 0.28	0.861	ns, p > 0.05
Appereance	4.21 ± 0.20	4.00 ± 0.26	0.632	ns, p > 0.05
The difference of specific lamb taste	4.67 ± 0.31[a]	3.88 ± 0.26[b]	1.961	*, p < 0.05
Overall difference	5.50 ± 0.28[a]	3.92 ± 0.34[b]	3.616	***, p < 0.001

[a,b] Means in the same line with different superscripts are significantly different.

Meat tenderness can be affected by the structure of the connective tissue, carcass fatness and collagen levels of meat (Sañudo et al., 2000; Díaz et al., 2002). The diet did affect the meat juiciness, tenderness, the difference of specific lamb taste and overall difference in the current study. Moreover, there were positive and very significant correlations (p <0.001) between tenderness and juiciness and between tenderness and flavor. Positive and very significant correlations (p <0.001) were also recorded between juiciness, tenderness, aroma and specific lamb taste according to the Pearson correlation results (Table 9).

Table 9. Coefficient of correlation among for meat sensory characteristic

Characteristics	Juiciness	Tenderness	Flavor	Appereance	The difference of specific lamb taste	Overall difference
Juiciness	1.00					
Tenderness	0.77***	1.00				
Flavor	0.49***	0.70***	1.00			
Appereance	0.27	0.42	0.46***	1.00		
The difference of specific lamb taste	0.57***	0.61***	0.58***	0.43	1.00	
Overall difference	0.62***	0.63***	0.53***	0.38	0.55***	1.00

*** $P < 0.001$.

CONCLUSIONS

We found that growth rate, carcass weight, dressing percentages are influenced by the diet. On the other hand, the lambs fed higher level of protein during entire fattening period had higher values in terms of lean/bone and lean/fat ratio than lambs fed smaller level of protein. Furthermore, results of sensory analyses indicate that the meat was juicier and more tender in the lambs fed with a higher protein level compared to the lambs fed with a smaller protein level.

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