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THE EFFECT OF FEEDING SYSTEM ON THE CARCASS QUALITY OF CROSSBRED LAMBS WITH TEXEL

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Abstract

The aim of this study was to estimate the effect of feeding system on the growth rate and carcass quality of crossbred Improved Jezersko-Solčava x Texel (JSRT) lambs and to evaluate the effect of sex on these traits. The trial was conducted *in nature* according to the traditional rearing systems. The trial included 44 crossbred lambs, which were born and reared until the slaughter in three different flocks. In the age of 10 days suckled lambs were offered with *ad libitum* corresponding diets according to the feeding system. All lambs were slaughtered in seven consecutive days by the same procedure. The effect of feeding system significantly affected daily gain from birth to slaughter, EUROP carcass conformation and shoulder width. Likewise, the effect of sex significantly affected daily gain from birth to slaughter and internal fatness of carcasses. According to carcass cuts the feeding system significantly affected only the proportion of neck and leg. Considering meat quality traits, feeding system had a significant effect on the pH 45 and CIE a* values. In this study, we could speculate that more than the feeding system the growth and the carcass traits as well as meat traits were affected by the amount of the supplement.

Keywords: carcass characteristics, lamb meat, commercial crossing, Improved Jezersko-Solčava sheep, Texel sheep, feeding system

INTRODUCTION

In Slovenia, the lamb meat production is still insufficient, despite the lamb meat consumption is low (SURS, 2019). To increase them, the lamb meat market should be well organized. Priority activities in lamb meat sector are oriented towards the sustainable production system. Nowadays, lamb production is based on the traditionally reared autochthonous Jezersko-Solčava sheep (JS) and Improved Jezersko-Solčava with Romanov sheep (JSR). In order to improve the lower carcass quality of JSR (Cividini *et al.*, 2012) the commercial crossing with Texel (T) is used. Commercial crossing is well known method among sheep breeders in different continents. Mainly are used a maternal local breeds of dams and a terminal meat breed of sires like Texel (Bernes *et al.*, 2012; Cardoso *et al.*, 2013) and Ile de France (Barone *et al.*, 2007).

The main production system used by Slovenian breeders is grazing lambs on the pasture with their mothers until they reach 25 to 30 kg of slaughter weight. Grazing lambs are highly valued by consumers for their good meat quality, especially lower carcass fatness and higher percentage of linoleic (C18:2n-6), α-linolenic (C18:3n-3), arachidonic (ARA) (C20:4n-6), and eicosapentaenoic (EPA) (C20:5n-3) fatty acids (Cividini *et al.*, 2007; Cividini *et al.*, 2008). Unfortunately, grazing lambs are produced only during the vegetation season. The other production system in Slovenia is fattening lambs in the stable during the winter season. Lambs are fattened with hay, second harvest or silage and concentrate or grains. In the winter season, lambs are weaned at around 60 days of age and then fattened till the slaughter weight of 30, 35 or 40 kg, depends on the breed. During the fattening period, the feeding systems differed in the diet (the quality and quantity) among breeders. The climate conditions and the relief of agricultural land in pre-alpine areas do not allow the required production of good quality hay and a second harvest. Consequently, the quality of forage may vary between seasons and breeders. Because of different feeding systems lamb carcass quality have some specificity attributed to a particular region and/or feeding system.

In lamb production, more than in any other species, each country or region has determined a specific type of carcass, depending on the consumer demand and the production system (Sanudo 1998). Carcass quality is also effected by the breeder and his preference of fattening technology (Santos-Silva *et al.*, 2002), feeding system (Carrasco *et al.*, 2009), feeding type (Barone *et al.*, 2007), milk feeding regime (Lanza *et al.*, 2006) and lambs genotype, purebred *vs.* crossbred (Carrasco *et al.*, 2009).

In the past years, some studies have been performed on the sheep breeds reared in Slovenia, in particular Texel crossbreds for lamb meat production, with the aim to evaluate the effect of crossbreeding on the carcass quality. Cividini *et al.* (2004) found that commercial crossing of JSR ewes with Texel rams significantly improved carcass quality of crossbred (JSRT) lambs. However, there is a lack of information about feeding systems of fattened crossbred lambs, and scarce information about their growth and carcass quality.

The aim of this study was to estimate the effect of feeding system on the growth rate and carcass quality of weaned crossbred JSRT lambs and to evaluate the effect of sex on these traits.

MATERIALS AND METHODS

Animal Management

The trial was conducted *in nature* according to the traditional rearing, weaning and feeding systems, from March to May 2019. The trial included 44 crossbred lambs (Improved Jezersko-Solčava sheep with Romanov sheep (JSR) x Texel sheep (T)) where 23 males and 21 females were. Lambs of both sexes were born and reared until the slaughter in three different flocks. Lambs in all three flocks were kept together with their mothers in the stable until weaning. In the age of 10 days suckled lambs were offered with *ad libitum* corresponding diets according to the feeding system (HSC; HCC; SHCB) precisely described in the Tab. I. Flocks were located in the Central East part of Slovenia, two of them in Zasavje region and one in Savinja region. The distance among most distant flocks were 56 km.

In the first flock, the experimental group of lambs included 16 JSRT lambs (10 males and 6 females) fattened with hay, grass silage and corn in the ratio 15:50:35. This group of lambs were assigned as hay/silage/corn (HSC) feeding system. In the second flock, the experimental group of lambs included 13 JSRT lambs (8 males and 5 females), where hay and commercial concentrate in the ratio 30:70 were used. The second group of lambs were assigned as hay/commercial concentrate feeding system (HCC). The commercial concentrate contained 18% crude

I: *The composition of feeding ratio and the daily feed intake of crossbreed JSRT lambs during the fattening period in three different feeding systems*

Feeding ratio	Composition (g/day/lamb)	Day 1	Day 10	Day 20	Day 30	Day 40	Day 50	Day 60	Day 70	Day 80
HSC	Hay I	250	250	310	310	340	375	250	250	260
	Silage	575	590	575	720	800	860	850	1000	1000
	Corn	780	840	940	940	1000	1180	1200	1200	1200
	Total daily feed intake	1605	1680	1825	1970	2140	2415	2300	2450	2460
HCC	Hay II	340	400	500	530	710	730	700	700	/
	CC	1200	1400	1600	1600	1600	1600	1700	1750	/
	Total daily feed intake	1540	1800	2100	2130	2310	2330	2400	2450	/
SHCB	Second harvest	900	1100	1200	1350	1500	1570	/	/	/
	Corn	530	300	260	420	420	420	/	/	/
	Barley	530	300	260	420	420	420	/	/	/
	Total daily feed intake	1960	1700	1720	2190	2340	2410			

HSC – hay/silage/corn, HCC – hay/commercial concentrate, SHCB – second harvest/corn/barley feeding system
CC – commercial concentrate

II: *Descriptive statistics for body weights, ages, daily gain from birth to slaughter and fattening period of crossbreed JSRT lambs according to the feeding system*

Feeding system	N	Trait	Mean	SD	Min	Max
HSC	16	Birth weight, kg	4.57	0.71	3.70	6.00
		Weaning weight, kg	21.50	1.66	18.90	23.90
		Slaughter weight, kg	36.31	3.48	32.40	45.50
		Age at weaning, days	59.75	9.18	43.00	75.00
		Age at slaughter, days	134.25	14.98	116.00	160.00
		Fattening period, days	74.50	10.84	64.00	85.00
		Daily gain from birth to slaughter, g/day	238.54	32.59	196.87	298.32
HCC	13	Birth weight, kg	4.41	0.58	2.60	4.90
		Weaning weight, kg	21.88	4.64	17.50	32.50
		Slaughter weight, kg	40.20	4.27	33.50	47.00
		Age at weaning, days	66.31	10.06	53.00	90.00
		Age at slaughter, days	123.54	9.00	110.00	137.00
		Fattening period, days	57.23	10.21	47.00	70.00
		Daily gain from birth to slaughter, g/day	290.37	32.33	241.32	346.34
SHCB	15	Birth weight, kg	3.86	0.80	3.00	5.80
		Weaning weight, kg	26.14	3.14	21.50	32.00
		Slaughter weight, kg	36.27	2.75	30.50	41.00
		Age at weaning, days	94.46	10.14	71.00	106.00
		Age at slaughter, days	137.53	11.38	121.00	161.00
		Fattening period, days	43.06	10.39	34.00	55.00
		Daily gain from birth to slaughter, g/day	236.65	24.53	203.95	277.37

HSC – hay/silage/corn feeding system, HCC – hay/commercial concentrate feeding system, SHCB – second harvest/corn/barley feeding system, N – number of records, SD – standard deviation, Min – minimum, Max – maximum

protein and 10.0 MJ/kg metabolizable energy. In the third flock, the experimental group of lambs included 15 JSRT lambs (5 males and 10 females) where the second harvest, corn and barley in the ratio 60:20:20 were used. The third group of lambs were assigned as second harvest/corn/barley feeding system (SHCB).

The experimental procedure was the same in all three flocks. Lambs in all three flocks were kept together with their mothers in the stable until weaning. One week before the weaning was planned, lambs were randomly assigned by sex and live weight at each location. The weaning occurred at the average age of 73.52 days and the average weaning weight of 23.19 kg. Lambs weaning age and weaning weight differed slightly among flocks (Tab. II). Immediately after weaning, lambs were allocated in separated pens and continuously fed with HSC in the first flock, HCC in the second flock and SHCB in the third flock. The amount of hay, grass silage, second harvest, grain or concentrates in the daily feeding ratio were weighted every 10th day during the fattening period. The rest of the daily feeding ration in mangers were also weighted to estimate the daily feed intake per pen. Mineral-vitamin mixture and water were available *ad libitum*. The target slaughter weight for lambs in each flock was 37 kg.

Slaughtering and Carcass Measurements

On the day of the slaughter, lambs were weighted in the stable, just before the transportation to the commercial slaughter house. The distances to the slaughter house were 50 km, 40 km and 46 km from the first, second and third location, respectively. Daily gain from birth to the slaughter was calculated from body weights and slaughter age. All lambs were slaughtered in seven consecutive days by the same procedure. All lambs were electrically stunned and slaughtered according to the standard commercial procedure. After the slaughter, hot carcass weight (HCW) was recorded and a dressing percentage was computed as hot carcass weight divided by slaughter weight. HCW was defined as weight of the whole carcass after bleeding, removing entrails, head, pelt, forefeet, hind feet, tail and udder. Kidney with kidney fat and knob channel fat belongs to the carcass.

Carcasses were kept at 17 °C for 2 h, and then were chilled at 4 °C for the next 24 h. After that cold carcass weight (CCW), carcass length (CL), leg width (LW) and shoulder width (SW) were measured. Carcass length (CL) was recorded from the cranial edge of the symphysis pelvis to the cranial edge of the first rib. Leg width (LW) and shoulder width (SW) were defined as the largest width of legs or shoulder, measured in a horizontal plane on the hanging carcass. Carcass conformation was subjectively scored on the scale from 15 for E+ (excellent) to 1 for P- (poor) of the EUROP classification (E – excellent, U – very good, R – good, O – fair and P – poor), while fatness degree was scored in the scale from 1 (1-, very low) to 15 (5+, very high) of the classification system (1 – low, 2 – slight, 3 – average, 4 – high and 5 – very high). Two different kind of fatness were scored, subcutaneous as well as internal one. The pH of the *M. longissimus dorsi* (LD) on the carcass right side was recorded 45 min (pH 45) and 24 h (pH 24) *post-mortem* behind the last rib using a pH-meter equipped with a penetrating electrode.

Carcasses were further cut into seven cuts: neck, chuck, back, loin, shoulder, leg and rib with flank. Each cut was weighted and expressed as percentage of CCW. The weight of kidney and kidney fat were also recorded. Meat color was measured as triplicate on the cross section of LD muscle after 30 min of exposure to the air by chromo meter (Minolta CR 300) and expressed as CIE L*a*b* values.

Statistical Analysis

Statistical analysis was performed by a general linear model (GLM) procedure using SAS/STAT® Software Version 9.4 (SAS Inst. Inc., 2014). The following model (1) for the carcass quality (y_{ijk}) considered the feeding system (F_j) (j = 1, 2, 3) and the sex (S_i) (i = male, female) as fixed effects. Slaughter weight was included in the model as linear regression. Least square means were compared at the 5% probability level.

$$y_{ijk} = \mu + F_i + S_j + b(x_{ijk} - \bar{x}) + e_{ijk} \quad (1)$$

RESULTS

In this study, least square means for the daily gain from birth to slaughter, carcass traits, weights of carcass cuts and meat quality were estimated at 37 kg of slaughter weight. LSMeans for the daily gain from birth to slaughter and carcass traits are shown in Tab. III. The effect of feeding system significantly affected daily gain from birth to slaughter (P < 0.01), EUROP carcass conformation (P < 0.01) and shoulder width (P < 0.05). The growth of crossbred lambs were faster in the feeding system with hay and commercial concentrate (271 ± 6.36 g/day). Regarding the subjective scoring, the feeding system affected only the EUROP conformation (P < 0.01). The EUROP conformation significantly differed between HSC and SHCB feeding system with the highest average conformation score in crossbred lambs fed with hay/silage/corn (9.5 ± 0.25). Likewise,

III: *Daily gain from birth to slaughter and carcass traits of crossbred JSRT lambs of both sexes according to different feeding systems (LSMeans ± SE)*

Carcass traits	Feeding system (F)			Sex (S)		Sig.	
	HSC (N = 16)	HCC (N = 13)	SHCB (N = 15)	Male (N = 23)	Female (N = 22)	F	S
DG, g/day	240 ± 5.22[a]	271 ± 6.36[b]	243 ± 5.39[a]	260 ± 4.49[a]	243 ± 4.56[b]	**	*
HCW, kg	17.7 ± 0.23	18.0 ± 0.28	17.8 ± 0.24	17.6 ± 0.19	18.1 ± 0.20	ns	ns
CCW, kg	17.2 ± 0.22	17.7 ± 0.26	17.3 ± 0.22	17.1 ± 0.18	17.6 ± 0.19	ns	ns
DP, %	47.9 ±0.63	48.8 ± 0.77	48.2 ± 0.65	47.6 ± 0.54	48.9 ± 0.55	ns	ns
EUROP	9.5 ± 0.25[a]	8.8 ± 0.30[ab]	7.9 ± 0.25[b]	8.5 ± 0.21	8.9 ± 0.22	**	ns
SFAT, 1-15	9.1 ± 0.31	9.3 ± 0.37	8.6 ± 0.32	8.7 ± 0.26	9.3 ± 0.27	ns	ns
IFAT, 1-15	9.7 ± 0.38	9.4 ± 0.46	9.3 ± 0.39	8.7 ± 0.32	10.2 ± 0.33	ns	**
CL, cm	58.7 ± 0.35	58.4 ± 0.42	59.1 ± 0.36	58.5 ± 0.30	59.0 ± 0.30	ns	ns
LW, cm	20.1 ± 0.16	20.2 ± 0.20	20.1 ± 0.17	19.9 ± 0.14	20.3 ± 0.14	ns	ns
SW, cm	18.9 ± 0.26[a]	19.5 ± 0.32[ab]	20.1 ± 0.27[b]	19.3 ± 0.23	19.7 ± 0.23	*	ns

HSC – hay/silage/corn feeding system, HCC – hay/commercial concentrate feeding system, SHCB – second harvest/corn/barley feeding system, DG – daily gain from birth to slaughter, HCW – hot carcass weight; CCW – cold carcass weight, DP – dressing percentage, EUROP – conformation: E+ = 15, E_0 = 14, E- = 13, U+ = 12, U_0 = 11, U- = 10, R+ = 9, R_0 = 8, R- = 7, O+ = 6, O_0 = 5, O- = 4, P+ = 3, P_0 = 2, P- = 1, SFAT – subcutaneous fatness score: 5+ = 15, 5_0 = 14, 5- = 13, 4+ = 12, 4_0 = 11, 4- = 10, 3+ = 9, 3_0 = 8, 3- = 7, 2+ = 6, 2_0 = 5, 2- = 4, 1+ = 3, 1_0 = 2, 1- = 1, IFAT – internal fatness score: 5+ = 15, 5_0 = 14, 5- = 13, 4+ = 12, 4_0 = 11, 4- = 10, 3+ = 9, 3_0 = 8, 3- = 7, 2+ = 6, 2_0 = 5, 2- = 4, 1+ = 3, 1_0 = 2, 1- = 1, CL – carcass length, LW – leg width, SW – shoulder width, * P < 0.05, ** P < 0.01, *** P < 0.001, ns – not significant. Values in the same row inside feeding system or inside sex with different superscripts are statistical significant (P < 0.05).

IV: *The effect of slaughter weight on carcass traits of crossbred JSRT lambs*

	HCW, kg	CCW, kg	IFAT, 1-15	CL, cm	LW, cm	SW, cm
b ± SEE	0.42 ± 0.04	0.42 ± 0.04	0.17 ± 0.07	0.31 ± 0.06	0.15 ± 0.04	0.20 ± 0.05
Sig.	***	***	*	***	***	***

HCW – hot carcass weight, CCW – cold carcass weight, IFAT – internal fatness score: 5+ = 15, 5_0 = 14, 5- = 13, 4+ = 12, 4_0 = 11, 4- = 10, 3+ = 9, 3_0 = 8, 3- = 7, 2+ = 6, 2_0 = 5, 2- = 4, 1+ = 3, 1_0 = 2, 1- = 1, CL – carcass length, LW – leg width, SW – shoulder width, * P < 0.05, ** P < 0.01, *** P < 0.001, b – linear regression coefficients, SEE – standard error, Sig – significance

significant difference among feeding systems were also obtained for shoulder width, where the widest shoulders had lambs from the SHCB feeding system.

Likewise, the effect of sex significantly affected daily gain from birth to slaughter (P < 0.05) and internal fatness of carcasses (P < 0.01) (Tab. III). Male lambs were grown faster from birth to 37 kg of slaughter weight in comparison with female lambs (260 g/day *vs* 243 g/day). Subjectively classification of carcasses showed, that male carcasses had lower internal fatness in comparison with female carcasses (8.7 *vs* 10.2).

The effect of the slaughter weight on carcass traits is presented in Table IV where only those traits were considered where it was significant. In this study, the slaughter weight significantly affected hot as well as cold carcass weights, internal fatness, carcass length, shoulder width and leg width. All shown traits increased significantly with the increased slaughter weight.

According to carcass cuts the feeding system significantly affected (P < 0.05) only the proportion of neck and leg (Tab. V). The proportion of neck differed only between lambs from HSC and HCC feeding systems, with the highest proportion of neck in HSC carcasses (7.2 ± 0.10%). The proportion of leg differed only between lambs from HSC and SHCB feeding systems with the highest proportion of leg in HSC carcasses (31.9 ± 0.22%). The difference was significant (P < 0.001) also in the proportion of kidney which was the highest in HCC carcasses (0.71 ± 0.02%) and very similar in HSC (0.54 ± 0.02%) and SHCB (0.53 ± 0.02%) carcasses. Feeding system affected kidney fat proportion (P < 0.01) as well. Lambs fattened with hay and commercial concentrate (HCC) had the highest kidney fat proportion (2.08 ± 0.17%) and differed significantly only with lambs fattened with hay, silage and corn (HSC, 1.37 ± 0.14%), where the lowest proportion of the kidney fat was recorded. As expected, male lambs had significantly higher proportion of neck (P < 0.01) and shoulders (P < 0.05) in comparison with female lambs. Likewise, a significant difference in kidney (P < 0.001) and kidney fat (P < 0.01) proportions were observed where males had larger proportion of kidney and lower proportion of kidney fat compared to females.

Considering meat quality traits (Tab. VI), feeding system had a significant effect on the pH 45 (P < 0.05) and CIE a* (P < 0.01) values. The highest value of pH 45 was observed in the carcasses of HSC lambs, followed by HCC and SHCB lambs, where significant differences were observed

V: *Carcass cuts, kidney and kidney fat proportions of crossbred JSRT lambs of both sexes according to different feeding systems (LSMeans ± SE)*

Carcass cuts	Feeding system (F)			Sex (S)		Sig.	
	HSC (N = 16)	HCC (N = 13)	SHCB (N = 15)	Male (N = 23)	Female (N = 22)	F	S
Neck, %	7.2 ± 0.10[a]	6.8 ± 0.13[b]	7.1 ± 0.11[ab]	7.3 ± 0.09	6.8 ± 0.09	*	**
Chuck, %	3.4 ± 0.10	3.6 ± 0.12	3.6 ± 0.10	3.7 ± 0.08	3.4 ± 0.08	ns	ns
Shoulder, %	16.9 ± 0.17	17.0 ± 0.21	17.2 ± 0.17	17.3 ± 0.15	16.8 ± 0.15	ns	*
Back, %	7.4 ± 0.13	7.5 ± 0.16	7.4 ± 0.14	7.3 ± 0.11	7.5 ± 0.12	ns	ns
Loin, %	7.7 ± 0.13	7.4 ± 0.16	7.3 ± 0.14	7.4 ± 0.11	7.5 ± 0.12	ns	ns
Rib and flank, %	23.5 ± 0.25	23.3 ± 0.30	23.9 ± 0.26	23.7 ± 0.21	23.5 ± 0.22	ns	ns
Leg, %	31.9 ± 0.22[a]	31.6 ± 0.27[ab]	31.1 ± 0.23[b]	31.3 ± 0.19	31.7 ± 0.19	*	ns
Kidney, %	0.54 ± 0.02[a]	0.71 ± 0.02[b]	0.53 ± 0.02[a]	0.63 ± 0.01	0.56 ± 0.01	***	**
Kidney fat, %	1.37 ± 0.14[a]	2.08 ± 0.17[b]	1.81 ± 0.14[ab]	1.41 ± 0.12	2.10 ± 0.12	**	**

HSC – Hay/silage/corn feeding system, HCC – hay/commercial concentrate feeding system, SHCB – second harvest/corn/barley feeding system, * P < 0.05, ** P < 0.01. *** P < 0.001, ns – not significant. Values in the same row inside feeding system or inside sex with different superscripts are statistical significant (P < 0.05).

VI: *Meat quality traits of crossbred JSRT lambs of both sexes according to different feeding systems (LSMeans ± SEE)*

Meat quality traits	Feeding system (F)			Sex (S)		Sig.	
	HSC (N= 16)	HCC (N = 13)	SHCB (N=15)	Male (N = 23)	Female (N = 22)	F	S
pH 45	6.61 ± 0.04[a]	6.47 ± 0.05[ab]	6.40 ± 0.05[b]	6.52 ± 0.04	6.47 ± 0.04	*	ns
pH 24	5.54 ± 0.02	5.58 ± 0.03	5.60 ± 0.02	5.58 ± 0.02	5.57 ± 0.02	ns	ns
CIE L*	40.51 ± 0.55	39.88 ± 0.67	39.83 ± 0.57	40.23 ± 0.47	39.92 ± 0.48	ns	ns
a*	19.18 ± 0.46[a]	17.12 ± 0.56[b]	17.73 ± 0.47[ab]	17.82 ± 0.39	18.19 ± 0.40	*	ns
b*	7.74 ± 0.27	7.34 ± 0.32	7.31 ± 0.27	7.39 ± 0.23	7.53 ± 0.23	ns	ns

HSC – Hay/silage/corn feeding system, HCC – hay/commercial concentrate feeding system, SHCB – second harvest/corn/barley feeding system, pH 45 – pH 45 min after the slaughter, pH 24 – pH 24 h after the slaughter, * P < 0.05, ** P < 0.01, *** P < 0.001, ns – not significant. Values in the same row inside feeding system or inside sex with different superscripts are statistical significant (P < 0.05).

only between HSC and SHCB carcasses. Above all, HSC carcasses had the highest value of CIE a* and differed significantly with HCC carcasses. On the other hand, sex had no effect neither on the meat colour parameters nor on the pH value.

DISCUSSION

In this study, all three feeding ratios were composed from forage supplemented with concentrate or different grains. Forage feed slightly differed among feeding systems, where only hay were used in the HCC, while in the HSC hay and grass silage were included in the ratio. In the case of SHCB, there were used second harvest for feeding lambs. Based on the weighing of the leftovers in the manger, it was realised that lambs were fed forage *ad libitum*, while concentrate and grains were restricted in similar amounts. In the HSC feeding ratio, only corn was included for the supplementation, while in the SHCB feeding ratio there were corn and barley in the proportion of 50:50. The most sophisticated supplementation were fed in the HCC feeding ratio, where commercial concentrate mixture was used. According to specification it was composed from corn, sunflower cakes, soybean cakes, barley, lucerne, molasses, sugar beet, calcium carbonate, monocalcium phosphate and sodium chloride. However, all three feeding systems are very traditionally used in Slovenia, during the winter time were lambs are fattened indoors. Comparing all of them, corn were included in all three feeding rations. Besides the composition of the supplemented fed, there were observed the difference in the amount of the supplementation (Tab. I) among feeding systems as well. The HCC feeding system offered the highest amount of supplementation during all period including suckling period, weaning and fattening till slaughter, what could be a reason for the significantly highest daily gain of lambs from birth to the slaughter (271 ± 6.36 g/day). Likewise, EUROP carcass conformation was the highest (9.5 ± 0.25) in lambs from that system.

In a similar study, Bernes *et al.* (2012) compared crossbred rams (White Swedish Landrace x Texel) in different feeding systems from birth to weaning. Crossbred lambs fed with grass silage and concentrate (whole barley, crushed peas, rapeseed cake) before weaning and after it, were slaughtered at 39.3 kg of slaughter weight and achieved 292 g/day of daily gain. Similarly, Casas *et al.* (2005) reported daily gains of different crossbred lambs where F_1 lamb from composite breed ewes crossed with Texel rams achieved 267 g/day based on total mixed diet. Cardoso *et al.* (2013) studied crossbred lambs of Brazilian local breed Santa Ines ewes mated with Texel. Lambs were fed hay and concentrates after weaning. After the slaughter they recorded similar values of carcass traits in Santa Ines x Texel lambs compared to HCC fed lambs in this study, as follows hot carcass weight (19.20 kg *vs.* 18.0 ± 0.28 kg) and cold carcass weight (18.68 kg *vs.* 17.7 ± 0.26 kg).

The effect of the sex on the growth in this study was significant, where males grown faster compared to females (260 ± 4.49 g/day *vs.* 243 ± 4.56) and had lower internal fatness (8.7 ± 0.32 *vs.* 10.2 ± 0.33) at slaughter. Both traits were in agreement with Cividini *et al.* (2005) and Sañudo *et al.* (1998). Cividini *et al.* (2005) found higher daily gain and lower internal fatness in males (272 ± 10 g/day; 4.87 ± 0.38) compared to females (240 ± 10 g/day; 6.80 ± 0.36) of purebred JSR and JSR x Charollais crossbred lambs. Likewise, Sañudo *et al.* (1998) recorded higher daily gain and lower visual fatness in males (244 g/day; 3.0) compared to females (210 g/day; 3.4) of local meat breed Rasa Aragonesa. The subjectively scored lower internal fatness in males from this study was confirmed by the proportion of kidney fat in carcasses, which was lower in males (1.41 ± 0.12%) compared to females (2.10 ± 0.12%) and was in agreement with other authors. Cividini *et al.* (2005) determined higher proportion of kidney fat in females (1.79 ± 0.10%) compared to males (1.22 ± 0.10%) of purebred JSR and JSR x Charollais crossbred lambs. Similarly, Barone *et al.* (2007) determined higher proportion of kidney fat in females (1.47 ± 0.78%) compared to males (1.17 ± 0.56%) of Gentile di Puglia x Ile de France crossbred lambs.

In this study, meat colour parameters and pH values was instrumentally measured as well, but there were no differences in meat traits between sexes. These findings are in agreement with previous study, which found no effect of sex on pH (Sañudo *et al*. 1998).

CONCLUSION

In this study, three similar feeding systems were investigated where all of them included the same genotype of lambs. Likewise, all three feeding ratios were composed from similar forage from grasslands and with different supplement. Lambs fattened with hay and commercial concentrate (HCC) have grown faster than lambs from the other two feeding systems (HSC, SHCB), while their carcasses have the highest percentage of kidney and kidney fat. In this study, the hay/silage/corn feeding system (HSC) produced the best carcasses with higher neck and leg percentages, better EUROP conformation with more intensive red meat colour. However, carcasses from the second harvest/corn/barley (SHCB) feeding system were wider in shoulders than carcasses from hay/silage/corn (HSC) feeding system. When compared males and females, male lambs have grown faster in all three feeding systems and their carcasses had lower internal fatness compared to females. According to all above we can conclude that HCC feeding system produced fatter lambs, especially females. We recommend to slaughter female lambs earlier than males, as internal fatness increased with the slaughter weight. The hay/silage/corn (HSC) feeding system in ratio 15:50:35 could resulted in higher carcass quality traits in comparison with HCC and SHCB feeding systems. Further investigation should be done to determine the effect of the amount of the supplement.

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