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Some slaughter and meat traits of lambs and kids from an extensive production system

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ABSTRACT

The aim of this research was to evaluate the influence of species, sex and slaughter weight (≤24 kg; >24 kg) on the slaughter characteristics, carcass measurements, meat pH and meat colour of Dalmatian Pramenka lambs and Croatian Spotted Goat kids. 92 lambs and 90 kids of both sexes were used in this study. The animals were reared under an extensive production system on pasture, and were with their mothers until slaughter. Dalmatian Pramenka lambs had higher (P<0.001) carcass weight, dressing percentage, skin with lower legs weight and weight of all analyzed internal organs (except spleen) than Croatian Spotted Goat kids. Slaughter weight had a significant influence (P<0.001) on carcass weight and the weight of skin with lower legs and all internal organs, except the spleen. Females had higher dressing percentage (P<0.01) and lower skin with lower legs weight (P<0.05) than males. Species significantly influenced all investigated carcass measurements, except thoracis depth, in that the lambs' carcasses were more developed than those of the kids. The significant (P<0.001; P<0.01) influence of slaughter weight was evident in all carcass measurements in that animals with higher slaughter weight had more developed carcasses. Male animals had greater hind limb length (P<0.01) than female animals. Species (P<0.05) and slaughter weight (P<0.001) had a significant influence on the pH of *m. longissimus dorsi*. Dalmatian Pramenka lambs had lighter meat with greater (P<0.001) L* values of *m. rectus abdominis* (MRA) and *m. semitendinosus* (MS) than Croatian Spotted Goat kids. Redness (a*) of MRA was significantly (P<0.001; P<0.05) affected by species and slaughter weight, respectively. Males had greater (P<0.001) L* value of MRA than females, as well as b* value of MS (P<0.01).

K**ey words:** lamb, kid, carcass, meat, pH, colour

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Introduction

Sheep and goats are mostly farmed under traditional, extensive and semi-intensive systems around the world. Sheep and goat meat production in Croatia, as well as in other Mediterranean countries, is based on indigenous breeds, well adapted to the local environmental conditions. In the Mediterranean region of Croatia, sheep and goats are mainly farmed under extensive or semi-extensive systems based on natural pastures. The main features of those systems are minimum investment in facilities, equipment and nutrition. Throughout the year the animals are kept outside, staying on natural pastures and mountains slopes but during bad weather and cold days in the winter they are mainly kept in stables and fed with hay. The two most predominant indigenous breeds in Croatia, farmed as described, are Dalmatian Pramenka sheep and the Croatian Spotted Goat, which mainly reside in the same broad area of breeding. This is the area of the Adriatic coast, the Dalmatian hinterland, and the Velebit and Dinara Mountains, which is characterized by rocky ground and stone, poor vegetation, low thickets and underbrush, and there are very few possibilities for breeding other types of stock (except sheep), especially larger stock such as cattle (MIOČ et al., 2009; PRPIĆ et al., 2010).

Dalmatian Pramenka is a small, Mediterranean sheep breed with average body weight of 38 kg in ewes and 50 kg in rams (ŠIRIĆ et al., 2009). The head and legs are usually black pigmented although some animals can have a white head, ears and legs or a spotty white head and legs. The body is covered with an open, mostly white, rarely black, brown or grey fleece (MIOČ et al., 2007). According to the Croatian Agricultural Agency (ANONYM., 2011), the estimated population of Dalmatian Pramenka breed is 200,000 animals, with 9,304 animals under selection control. The average litter size of this indigenous sheep is 1.04 lambs (ANONYM., 2011). Lambs achieve a body weight of 18 kg at 87 days (VNUČEC et al., 2009).

The Croatian Spotted Goat is a medium sized breed with average body weight of 44 kg in does and 51 kg in bucks. The body (except the legs) is covered with long, thick, shiny, rough hair, usually multicoloured (black-white, brown or grey-white colour) and rarely of a single colour (MIOČ et al., 2008). The average litter size is 1.17 kids (ANONYM., 2011). With average birth weight of 2.3 kg, kids of the Croatian Spotted Goat reach 24 kg after 190 days of life and thereby achieve average daily gain of 112 grams (PRPIĆ et al., 2010; MIOČ et al., 2011). The estimated population size is 40,000 animals, with 510 animals under selection control (ANONYM., 2011).

The acceptability of lamb and kid carcasses varies considerably in different parts of the world. Lamb carcasses of 16 to 23 kg are preferred in northern Europe, and very light carcasses from 4 to 8 or 8 to 12 kg from milk-fed lambs and from young lambs finished on concentrates, respectively, are preferred in the Mediterranean Basin (BERIAIN et al., 2000). In India, the local community specifically demands 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).

Although Dalmatian Pramenka sheep and the Croatian Spotted Goat are breeds of combined productive characteristics, they are mainly used for meat production, mostly lamb and kid meat (MIOČ et al., 2008; VNUČEC et al., 2009). The production of lamb and kid meat in Croatia is traditionally based on slaughtering light lambs and kids at 20 to 25 kg of live weight, at an age between 90 and 120 days (VNUČEC et al., 2011). Given the age and body weight of animals at slaughter, the resulting carcass weight is from 10 to 13 kg, which is the most requested on the Croatian market (MIOČ et al., 2007; PRPIĆ et al., 2010). Similar slaughter and carcass weights of lambs are preferred in other Mediterranean countries: in Spain lambs of 19 to 26 kg live weight are preferred (PEÑA et al., 2005), in Italy of 13 kg live weight (COZZI and RAGNO, 2003), and in Greece carcasses weighing from 6 to10 kg (SKAPETAS et al., 2006). Kids are slaughtered at lower live weights than lambs: in the Canary Islands at 5-6 kg live weight (ARGÜELLO et al., 2005), in Argentina at 10-12 kg live weight (BONVILLANI et al., 2010), in Portugal at 8-11 kg live weight (SANTOS et al., 2007) and in Italy at 10-11 live weight (TODARO et al., 2004).

Considering the fact that the desirable carcass weight on the Croatian market is between 10 and 13 kg, the aim of this study was to evaluate the influence of species, sex and slaughter weight on slaughter characteristics, carcass measurements, meat pH and colour in Dalmatian Pramenka lambs and Croatian Spotted Goat kids, with a live weight which allows this range of carcass weight.

Materials and methods

Ninety-two Dalmatian Pramenka lambs (41 males and 51 females) and 90 Croatian Spotted Goat kids (36 males and 54 females) were used in this study. All investigated animals were reared under the same conditions, extensively, on pasture with their mothers, and except mother's milk, hay, pasture and browsing, no additional feed was added. The lambs and kids were randomly assigned into two different slaughter weight groups: group I (≤24 kg) and group II (>24 kg). Group I included 42 lambs and 48 kids with average slaughter weight of 21.5 kg (in a range of 18 - 24 kg) and group II included 50 lambs and 42 kids with average slaughter weight of 27 kg (in a range of 24 - 30 kg). Over 12 hours before slaughter the animals were fasted with free access to water. Before slaughter, the lambs and kids were weighed to determine slaughter weight (SW). Slaughter was conducted at the authorized slaughterhouse, following the normal commercial procedure in Croatia. After slaughter and bleeding, the skin was peeled off the carcasses, the lower limb parts were cut off (at the carpal and tarsal joints) and the abdominal (forestomach, stomach, spleen, intestines and liver) and thoracic (trachea, lungs and hurt) cavity organs were removed. Immediately after slaughter the carcasses, individual internal organs

and skin with lower limb parts were weighed and the dressing percentage (DP) was determined. Then the following measurements of the carcasses were taken: carcass length - measured by a flexible measuring tape from the caudal edge of the last sacral vertebra to the dorso-cranial edge of the atlas (the first cervical vertebra); chest depth - the greatest depth, measured by callipers for measuring cavities at the horizontal level of the hanging carcass; chest and buttock width - the greatest width, measured by callipers for measuring cavities at the horizontal level of the hanging carcass; hind limb length - measured by a flexible measuring tape from the middle of the lump at the proximal end of the tibia to the distal end of tarsus.

Meat colour as L*, a* and b* values was measured on the surface of the m. rectus abdominis (MRA) and m. semitendinosus (MS) using a Minolta Chroma Meter CR-410, with a colour measuring area of 50 mm and standard meat illumination D65. The L* value relates to lightness; the a* value to a red-green hue where positive values relate to the red intensity; and the b* value to the yellow-blue where positive value relate to yellow. The pH was measured on the m. longissimus dorsi (MLD) between the 12^{th} and 13^{th} ribs within 45 minutes after slaughter, using a pH meter IQ 150 with puncture electrode 56/57-SS.

The data were analysed using the GLM procedure in SAS/STAT software (SAS, 2008) with a model that includes species (lambs; kids), sex (male; female) and slaughter weight (≤24 kg; >24 kg) as fixed effects. Effects were considered significant if $P<0.05$. The results are presented as the last square means (LSM) ± standard error (SE).

Results

The influence of species, slaughter weight and sex on the slaughter characteristics of Dalmatian Pramenka lambs and Croatian Spotted Goat kids are presented in Table 1. Carcass weight and dressing percentage were significantly ($P<0.001$) influenced by species, as well as the weight of the stomach and intestines, lungs and heart, liver, testicles and skin with lower legs. A greater carcass weight with a higher dressing percentage was determined in lambs compared to kids. Kids had a higher proportion of non-edible organs (testicles, stomach and intestines) while lambs had a higher proportion of edible organs (lungs and heart, spleen and liver). Slaughter weight had a significant influence ($P<0.001$) on the weight of the carcass, skin with lower legs and all internal organs except the spleen. Although heavier animals had a higher dressing percentage it was not significantly different between the two slaughter weight groups. There was no significant effect of sex on carcass and internal organ weights. Females had a higher dressing percentage ($P<0.01$) and lower weight of skin with lower legs ($P<0.05$) than males.

Table 1. Effect of species, slaughter weight and sex on slaughter characteristics of lambs and kids (LSMEAN ± SE)

Parameter	Species (Sp)		Slaughter weight (SW)		Sex		Level of significance		
	Lambs	Kids	≤24	>24	Male	Female	Sp	SW	Sex
Carcass weight (kg)	12.65 ± 0.13	11.73 ± 0.14	10.98 ± 014	13.40 ± 0.13	12.05 ± 0.14	12.33 ± 0.12	***	***	NS
Dressing percentage (%)	52.43 ± 0.31	48.10 ± 0.33	50.09 ± 0.33	50.44 ± 0.30	49.60 ± 0.34	50.93 ± 0.29	***	NS	**
Stomach and intestines (kg)	6.17 ± 0.10	7.76 ± 0.10	6.35 ± 0.10	7.58 ± 0.09	7.05 ± 0.11	6.88 ± 0.09	***	***	NS
Lungs and heart (kg)	0.63 ± 0.01	0.48 ± 0.01	0.52 ± 0.01	0.59 ± 0.01	0.56 ± 0.01	0.54 ± 0.01	***	***	NS
Spleen (kg)	0.08 ± 0.003	0.07 ± 0.003	0.07 ± 0.003	0.07 ± 0.003	0.07 ± 0.003	0.07 ± 0.003	NS	NS	NS
Liver (kg)	0.50 ± 0.01	0.45 ± 0.01	0.44 ± 0.01	0.51 ± 0.01	0.48 ± 0.01	0.47 ± 0.01	***	***	NS
Testicles (kg)	0.11 ± 0.01	0.19 ± 0.01	0.14 ± 0.01	0.17 ± 0.01	0.15 ± 0.01	-	***	*	-
Skin with lower legs (kg)	3.31 ± 0.04	2.24 ± 0.04	2.60 ± 0.04	2.95 ± 0.04	2.84 ± 0.04	2.71 ± 0.04	***	***	*

* P<0.05; ** P<0.01; *** P<0.001; NS - not significant

Table 2. Effect of species, slaughter weight and sex on carcass measurements of lambs and kids (LSMEAN ± SE)

Parameter	Species (Sp)		Slaughter weight (SW)		Sex		Level of significance		
	Lambs	Kids	≤24	>24	Male	Female	Sp	SW	Sex
Carcass length (cm)	65.54 ± 0.32	61.33 ± 0.34	62.63 ± 0.34	64.24 ± 0.31	63.59 ± 0.36	63.28 ± 0.30	***	***	NS
Thoracis width (cm)	13.91 ± 0.07	11.57 ± 0.08	12.39 ± 0.08	13.09 ± 0.07	12.71 ± 0.08	12.77 ± 0.07	***	***	NS
Thoracis depth (cm)	23.97 ± 0.12	23.82 ± 0.13	23.35 ± 0.13	24.44 ± 0.12	24.04 ± 0.14	23.75 ± 0.12	NS	***	NS
Hind limb length (cm)	25.49 ± 0.11	25.09 ± 0.12	25.03 ± 0.12	25.55 ± 0.11	25.51 ± 0.12	25.06 ± 0.10	*	**	**
Buttock width (cm)	14.49 ± 0.08	12.85 ± 0.09	13.37 ± 0.09	13.97 ± 0.08	13.67 ± 0.09	13.67 ± 0.08	***	**	NS

* P<0.05; ** P<0.01; *** P<0.001; NS - not significant

Table 3. Effect of species, slaughter weight and sex on pH and meat colour of lambs and kids (LSMEAN ± SE)

Parameter		Species (Sp)		Slaughter weight (SW)		Sex		Level of significance		
		Lambs	Kids	≤24	>24	Male	Female	Sp	SW	Sex
MLD	pH	6.30 ± 0.03	6.38 ± 0.03	6.42 ± 0.03	6.27 ± 0.03	6.34 ± 0.03	6.35 ± 0.03	*	***	NS
MRA	L*	51.60 ± 0.24	48.48 ± 0.25	50.20 ± 0.26	49.88 ± 0.23	50.72 ± 0.27	49.36 ± 0.22	***	NS	***
	a*	20.14 ± 0.19	18.88 ± 0.20	19.81 ± 0.10	19.20 ± 0.18	19.72 ± 0.21	19.30 ± 0.17	***	*	NS
	b*	-0.32 ± 0.14	-0.40 ± 0.15	-0.23 ± 0.15	-0.49 ± 0.14	-0.24 ± 0.16	-0.48 ± 0.13	NS	NS	NS
MS	L*	46.80 ± 0.27	45.31 ± 0.29	46.26 ± 0.29	45.85 ± 0.26	46.28 ± 0.30	45.82 ± 0.25	***	NS	NS
	a*	16.48 ± 0.18	16.46 ± 0.19	16.41 ± 0.19	16.54 ± 0.18	16.66 ± 0.20	16.29 ± 0.17	NS	NS	NS
	b*	1.27 ± 0.15	1.47 ± 0.16	1.32 ± 0.17	1.43 ± 0.15	1.72 ± 0.17	1.02 ± 0.14	NS	NS	**

* P<0.05; ** P<0.01; *** P<0.001; NS - not significant.

Species had a significant influence on all carcass measurements, except thoracis depth (Table 2). Lamb carcasses were more developed, with greater carcass length, thoracis depth, buttock width ($P<0.001$) and hind limb length ($P<0.05$), than kid carcasses. All carcass measurements were significantly ($P<0.001$; $P<0.01$) influenced by slaughter weight in that animals with higher slaughter weight had more developed carcasses. Hind limb length was greater ($P<0.01$) in males compared to females, while other carcass measurements did not differ significantly between sexes.

The influence of species, slaughter weight and sex on the pH and meat colour of lambs and kids are presented in Table 3. Species and slaughter weight significantly affected pH value ($P<0.05$; $P<0.001$, respectively). Lamb muscle had a lower pH than kid muscle, and a lower pH was determined in animals of higher slaughter weight. The influence of sex on pH values was not significant, although females had a greater pH value than males. Meat colour differed between the studied species. A significantly ($P<0.001$) lighter (L*) colour of m. rectus abdominis and m. semitendinosus was found in lambs compared to kids. Redness (a*) of MRA was pronounced in lambs, while other colour parameters did not differ between the studied species (Table 3). There was a significant ($P<0.05$) decrease in redness (a*) of MRA with an increase in slaughter weight. Sex affected lightness (L*) of MRA and yellowness (b*) of the MS, with males having significantly higher values than females.

Discussion

The significant influence of species on dressing percentage was similar to that in suckling lambs and kids reported by SANTOS et al. (2008), and to that in sheep and goats reported by TSHABALALA et al. (2003). However, SEN et al. (2004) stated that dressing yield, expressed in terms of empty live weight, was not significantly different between sheep and goats under semiarid conditions. The higher dressing percentage of lambs in this study was associated with heavier carcasses (Table 1) compared to the kids; similar results were reported by TSHABALALA et al. (2003) and SEN et al. (2004) in sheep and goats. Further, the greater weight of the stomach and intestines in Croatian Spotted Goat kids contributed to a reduction in the dressing percentage compared to Dalmatian Pramenka lambs. This is in agreement with SEN et al. (2004), who reported the relatively higher, but not statistically significant, weight of gastro-intestinal tract in goats (16%) compared to sheep (13%).

As was expected, higher slaughter weight contributed to higher carcass weight and the higher weights of the stomach and intestines, lungs and heart and liver. The influence of slaughter weight on those indicators was reported by MARICHAL et al. (2003) in kids of different slaughter weights. The effect of slaughter weight on dressing percentage was not significant, probably because the animals were slaughtered at lower weights or

compared in smaller weight ranges, which is in agreement with SANTOS-SILVA et al. (2002). However, some authors (MARICHAL et al., 2003; BERIAIN et al., 2000) reported a decrease in dressing percentage with the increase in slaughter weight, as the lightest animals did not have fully developed digestive tracts. As might be expected, heavier animals had heavier skin with lower legs weight ($P<0.001$), which may be attributed to the larger skin surface due to larger body size.

The significant influence of sex on dressing percentage was found in that females had a higher dressing percentage than the males (Table 1). Similar results were reported by PEÑA et al. (2005) in lambs and by MARKOVIĆ et al. (2011) in suckling kids, although the differences were not significant.

All investigated carcass measurements were influenced by species, expect thoracis depth (Table 2). Those differences may be attributed to possible differences in age or growth rates, considering the fact that mature Croatian Spotted Goat have higher average body weight and greater body dimensions than mature Dalmatian Pramenka sheep (MIOČ et al., 2008; ŠIRIĆ et al., 2009). The thoracis depth, buttock width and hind limb length of Dalmatian Pramenka lambs were similar to Segureña lambs slaughtered at a similar weight (PEÑA et al., 2005). In general, goat carcasses have poorer conformation than sheep carcasses, especially early in life (NAUDÉ and HOFMEYR, 1981). Animals of greater slaughter weight have more developed carcasses, with larger carcass measurements. Similar results were reported by MARICHAL et al. (2003) in kids and by PEÑA et al. (2005) in lambs. Sex only had a significant influence on hind limb length, which was longer in males compared to females. Greater buttock width and thoracis depth in male lambs were reported by PEÑA et al. (2005), while SANTOS et al. (2007) reported that there was no significant effect of sex on carcass measurement in suckling kids.

Lambs had a lower pH_{45} value of the m. longissimus dorsi then kids (Table 3). SEN et al. (2004) did not found statistically significant differences of pH_{45} between sheep and goats. SANTOS et al. (2008) reported that species had no effect on muscle pH measured 60 min. after slaughter, but when the measurement was made 24 h post mortem, kids had significantly greater pH values. Animals of higher slaughter weight had lower $pH_{45,}$ which was expected because of their greater glycogen content, which allowed for a higher drop in pH value. The effect of slaughter weight on pH values measured immediately after slaughter was not significant in kids (ARGÜELLO et al., 2005; MARICHAL et al., 2003) and in lambs measured 60 min after slaughter (TEIXEIRA et al., 2005). Sex had no significant influence on pH in kids and lambs, which is in accordance with ARGÜELLO et al. (2005) and TEIXEIRA et al. (2005) respectively.

The colour parameters of MRA, such as L* (lightness) and a* (redness) were significantly ($P<0.001$) affected by species in that lambs had lighter and redder abdominal muscle compared to kids. However, when meat colour was measured on MLD other

authors (SANTOS et al., 2008; SHERIDAN et al., 2003) reported that kid meat was significantly lighter and less yellow than lamb meat. Dalmatian Pramenka lambs had lighter and redder, but less yellow colour MRA compared to Lacha and Rasa Aragonesa breeds from Spain slaughtered at similar weights (BERIAIN et al., 2000). In this study species had a significant effect on the L* value of semitendinosus muscle, while a* and b* values did not differ significantly between lambs and kids. KADIM et al. (2003) reported lower L*, but higher a* and b* values of MS in male goats, compared to the Croatian Spotted Goat kids in our research. Slaughter weight had a significant effect on a* values of MRA in that animals slaughtered at lower weights had redder abdominal muscle. This is not in accordance with BERIAIN et al. (2000) who found a significant increase in redness (a*) with an increase in slaughter weight in Lacha and Rasa Aragonesa lambs. Lightness (L*) decreased with increasing slaughter weight, although the differences were not significant (Table 3). Decreasing lightness with increasing slaughter weight in lambs was reported by BERIAIN et al. (2000) and TEIXEIRA et al. (2005), and in kids by MARICHAL et al. (2003) and ARGÜELLO et al. (2005). Yellowness (b*) decreased on MRA, but increased on MS with increasing slaughter weight. BERIAIN et al. (2000) reported decreasing yellowness with increasing slaughter weight on MRA. Sex had a significant influence on lightness (L*) of MRA and yellowness (b*) of MS. SANTOS et al. (2008) reported that there was no significant effect of sex on meat colour of MLD, while TEIXEIRA et al. (2005) reported lighter (L*) MLD in females compared to males.

Conclusions

Species had a significant influence on all investigated slaughter characteristics in that lamb carcasses were heavier, with a greater dressing percentage than kid carcasses. Higher slaughter weight contributed to greater carcass weight and greater weight of all internal organs. Sex only significantly affected dressing percentage and skin with lower legs weight. Species and slaughter weight influenced carcass development and meat pH. Lightness (L*) was significantly influenced by species and sex, redness (a*) by species and slaughter weight, while yellowness (b*) was significantly influenced by sex. However, in future research work regarding the influence of species on carcass and meat traits, the maturity effect of the experimental animals should be evaluated.

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SAŽETAK

Cilj ovog istraživanja bio je utvrditi utjecaj vrste, spola i klaoničke mase (≤24 kg; >24 kg) na klaoničke pokazatelje, mjere trupa, pH i boju mesa janjadi dalmatinske pramenke i jaradi hrvatske šarene koze. Istraživanjem je obuhvaćeno ukupno 92 janjadi i 90 jaradi oba spola. Istraživana janjad i jarad držana je u ekstenzivnim uvjetima, pri čemu je u razdoblju do klanja zajedno s ovcama, odnosno kozama boravila na pašnjaku. Janjad dalmatinske pramenke imala je značajno (P<0,001) veću klaoničku masu, veći randman,

veću masu kože s donjim dijelovima nogu, kao i masu unutarnjih organa (osim slezene) nego jarad hrvatske šarene koze. Tjelesna masa pri klanju značajno je utjecala (P<0,001) na klaoničku masu i masu kože s donjim dijelovima nogu te masu unutarnjih organa, izuzev slezene. U ženskih je grla utvrđen veći randman (P<0,01) te manja masa kože s donjim dijelovima nogu (P<0,05) nego u muških grla. Vrsta je značajno utjecala na sve istraživane mjere trupa, osim dubine prsa, pri čemu su janjeći trupovi bili razvijeniji od jarećih. Utjecaj tjelesne mase pri klanju bio je izražen (P<0,001; P<0,01) u svih praćenih mjera trupa pri čemu su životinje s većom tjelesnom masom pri klanju imale razvijenije trupove. Mužjaci su imali dužu stražnju nogu (P<0,01) od ženki. Vrsta (P<0,05) i tjelesna masa pri klanju (P<0,001) su značajno utjecale na pH vrijednost m. longissimus dorsi. Meso janjadi dalmatinske pramenke bilo je svjetlije boje s višim (P<0,001) L* vrijednostima m. rectus abdominis (MRA) i m. semitendinosus (MS) od jaradi hrvatske šarene koze. Crvenilo (a*) MRA bilo je pod značajnim (P<0,001; P<0,05) utjecajem vrste i tjelesne mase pri klanju. U mužjaka je utvrđena veća (P<0,001) L* vrijednost MRA, kao i veća b* vrijednost MS-a (P<0,01) nego u ženki.

Ključne riječi: janjad, jarad, trupovi, meso, pH, boja