

CARCASS QUALITY ANALYSIS IN LATVIAN DARKHEAD SHEEP

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Summary. Out of sheep breeds in Latvia, Latvian darkhead (LD) belongs to local genetic resources. LD sheep belong to the mutton-wool type and LD meat production is important in Latvia.

The purpose of the research was to clarify what quality lamb carcass can be obtained from LD sheep. We used LD purebred rams up to one year of age, which were kept in comparable conditions, and selected live weight as the primary trait in slaughtered animals.

Results indicated that the age of LD breed rams had a significant effect on live weight of animals prior to slaughter as well as on muscular and fat tissue weight in the carcass. So when rams are slaughtered at the age of 6-12 months, the weight of muscular tissue and fat tissue in the carcass increases.

Rams up to 300 days of age had significantly lower live weight before slaughter (-8.8), slaughter weight (-4.8) and carcass right half weight (-2.2).

Carcass tissue analysis indicated that only muscular tissue weight and percentage muscular tissue in the carcass were significantly lower: -1.8 kg and -4.5% respectively. In other tissue groups, significant differences were not observed. The percentage of bony tissue but not bony tissue weight in the carcass was significantly different. Besides, it was significantly lower in carcass of the 2nd group rams.

In the carcasses of slaughtered LD breed rams the meat to bony tissue ratio was 3.5. In carcasses from rams up to 300 days of age the ratio was 3.0, indicating a lower meat proportion in the carcass. A significantly higher meat to bone ratio was obtained in carcasses of rams with a slaughter age above 300 days. So increasing animal age results in an increased meat to bony tissue ratio. Similar tendency was observed for the muscular to bony tissue ratio in carcasses, where on average it was 2.6 in all slaughtered rams, but in carcasses from rams up to 300 days of age it was 2.2, indicating a lower muscular tissue amount in the carcass.

A significant negative correlation was established between muscular tissue development and muscular tissue proportion in the carcass. A close positive correlation was found between fat tissue assessment and its proportion in the carcass. There was a tendency of carcasses with higher muscular tissue weight having a higher assessment of muscular tissue development. A negative correlation was found between assessment of fat tissue class and fat tissue/muscular tissue assessment, which indicates that the increase in value of one trait results in the decreased value of other trait.

Key words: Latvian darkhead sheep, rams, age, carcass quality.

LATVIJOS JUODAGALVIŪ AVIŪ SKERDENŪ KOKYBĒS TYRIMAI

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Santrauka. Iš visų Latvijos avių veislių Latvijos juodagalvės (LJ) priskiriamos vietiniams genetiniams ištekliams. Jos priskiriamos avienos-vilnos tipui o jų mėsos gamyba šalyje yra labai aktuali.

Šio tyrimo tikslas buvo nustatyti, kokios kokybės ėriukų skerdenas galima pagaminti iš Latvijos juodagalvių avių. Tyrimai atlikti su Latvijos juodagalvių veislės grynaveisliais aviniais iki vienerių metų. Jie buvo laikomi panašiomis sąlygomis ir parinkti pagal gyvą svorį, kaip vieną iš pagrindinių skerdžiamų gyvūnų savybių.

Tyrimų rezultatai rodo, kad LJ veislės avinų amžius prieš skerdimą turėjo įtakos gyvajam svoriui, taip pat raumeninio ir riebalinio audinio svoriui skerdenose. Kai skerdžiami 6 mėnesių–vienerių metų avinai, raumeninio ir riebalinio audinio svoris skerdenose yra didesnis. Avinų iki 300 amžiaus dienų gyvasis svoris prieš skerdimą buvo žymiai mažesnis (-8,8), skerdimo svoris (-4,8) ir dešinės skerdenų pusės svoris (-2,2).

Skerdenų audinių tyrimai parodė, kad tik raumeninio audinio svoris ir procentinis kiekis skerdenose buvo patikimai mažesni – atitinkamai 1,8 kg ir -4,5 proc. Kitose audinių grupėse patikimų skirtumų nepastebėta. Statistiškai nepatikimas buvo kaulinio audinio svorio skirtumas, tačiau jo procentas skerdenose skyrėsi patikimai. Be to, jis buvo patikimai mažesnis antrosios grupės avinų skerdenose.

Paskerstų Latvijos juodagalvių avinų mėsos ir kaulinio audinio santykis buvo 3,5, bet avinų iki 300 amžiaus dienų skerdenose jis buvo 3,0. Tai rodo pernelyg mažą mėsos ir didelį kaulinio audinio kiekį skerdenose. Taigi su amžiumi kinta mėsos ir kaulinio audinio santykis. Panaši tendencija pastebėta ir skerdenų raumeninio bei kaulinio audinio santykyje: vidutiniškai visose paskerstų avinų grupėse jis buvo 2,6, bet skerdenose, gautose iš avinų iki 300 amžiaus dienų - tik 2,2. Tai galima paaiškinti mažesniu raumeniniu audiniu skerdenose.

Statistiškai patikimas neigiamas koreliacinis ryšys nustatytas tiriant raumeninio audinio vystymąsi ir jo santykinį kiekį skerdenose. Teigiama koreliacija pastebėta tiriant riebalinį audinį ir jo santykinį kiekį skerdenose. Pastebėta, kad,

esant didesniam raumeninio audinio kiekiui skerdenose, jis greičiau vystosi. Neigiama koreliacija buvo tiriant riebalinio ir raumeninio audinio kiekį. Vadinasi, kurio nors audinio kiekiui didėjant, kito kiekis mažėja.

Raktažodžiai: Latvijos juodagalvės avys, avinai, amžius, skerdenos, kokybė.

Introduction. The goal set for sheep breeding in Latvia is development of stable breeding and processing sector, which is capable of producing quality and competitive output for domestic market and external trade.

The main tasks of this sector are as follows:

1. improvement of sheep breed according to affirmed program in genetic improvement of livestock using high grade brood material;
2. providing quality brood material for sheep breeders;
3. supply of sheep breeding output to local market.

Sheep meat is considered as high value and ecologically clean product as these domestic animals are fed on natural stock.

There are favourable conditions in Latvia for sheep breeding and it may become a significant sector of agriculture, which will contribute to additional employment in rural districts and bring real income. Latvian darkhead sheep (further on referred as LD) in Latvia are considered a mono breed. On 01.01.2006, in Agricultural data centre register there were included 3801 flock of sheep with total number of 58468 animals out of which 69% were registered as sheep of LD breed.

In 2005, 15 farms in Latvia having obtained status of breeding farm were engaged in reproduction of breeding material [Recording yearly results, 2005].

Work has been started on recording and investigation of genetic resources of Latvian agricultural animals. Out of sheep breeds bred in Latvia, LD belongs to local genetic resources. In LD sheep breed maintenance program there are included animals of pure bred, or animals with 75% LD blood. True-to-type traits are to be preserved for the maintenance of genetic identity. To realize this program, 500 ewes and 50 brood rams will be selected. [Normative documents, Genetic improvement of livestock, 2004].

A lot of organizations are involved in the preservation process of LG sheep breed and one of them is Society "Latvian Sheep breeders' association". In association, specialists in genetic improvement of livestock have made an inventory in sheep breeding farms and selected animals, which correspond to criteria of LD maintenance program. LD sheep breed belongs to meat-wool type sheep and meat production from them will be an actual question in Latvia.

Research goal: elucidate what quality lamb carcass can be obtained from LD sheep.

Material and methods of research. The first sheep slaughtering standards were adopted already in 1960 [U.S.D.A. 1960]. They based on the age of the slaughtered animal, breeding direction and class of assessment. Assessment of constitution, exterior, fat tissue and amount of meat were considered when determining class of assessment.

In Latvia, based on EU standards [EEC, Nr. 123/92; EEC, Nr. 461/93], sheep carcass classification standard [LVS 298; 2000] corresponding to EU standards has been elaborated and on 27.10.2000 affirmed by Agricultural products standardization technical commission. According to above-mentioned standard intended for slaughter animals by age are divided into two classes:

- L – lambs up to 12 months of age,
- S – the other sheep.

In carcass quality assessment the use of sheep carcass classification standard is recommended. In assessment of musculature development letter designations EUROP with the following meaning are used: E – perfectly developed, U – very well developed, R – well developed, O – medium-well developed, P – weakly developed musculature. The level of fat stratification is designated by numbers from 1 to 5, where 1 – very low, 2 – low, 3 – medium high, 4 – high, 5 – very high.

In order to subject assessment of muscular development to biometric processing, the following numerical values were used: E – 1, U – 2, R – 3, O – 4, and P – 5 [Hartjen, 1991]. Estonian researchers have used EUROP letter designations with the following numerical value: E – 5, U – 4, R – 3, O – 2, and P – 1 [Piirsalu, 2005]. So our chosen method is different and it should be considered when interpreting obtained results.

Fat tissue stratification already in the standard is given in numbers, and with this it coincides with research method used by researchers from Estonia and other countries [Piirsalu, 2005; Hartjen, 1991].

Lamb muscular tissue assessment by EUROP standard and fat tissue stratification is performed in all EU member states. Obtained results indicate that specialized beef breeds surpass local animal breeds [Abeyne, 1998; Javor, Kukovics, Nabradi et al., 1998].

In Latvia, for the time being there are only research results obtained, but these results confirm, that LD purebred lamb carcass assessment is lower compare to that of crosses with meat type breeds [Kairiša, Sprūžs, 2005].

In research we used LD purebred rams up to one year of age, which were raised in similar conditions, selecting live weight as the primary trait in slaughtered animals. Consumers in Latvia require lambs 40 – 50 kg in live weight. It was motivation to select rams for slaughter within the range of this live weight.

Prior to slaughter, for 12 h feed was not available to animals but access to water was free. Carcass weight of rams was determined just after slaughter. By carcass we understand body of a slaughtered animal after stitching and bleeding, without head, legs, udder, genitals and internal organs except kidney and kidney fat [LVS:298, 2000; Zinātnes un tehnoloģijas vārdnīca, 2001]. Slaughter result is the ratio of the carcass mass to animal live weight prior to slaughter expressed in percentage.

After assessment the carcass was halved. The right

side of the carcass was de-boned and divided in kind of tissue, and weighed separately: muscular tissue, bony tissue, fat tissue, and connective tissue.

Relationship between obtained tissue was calculated: meat (muscular tissue+fat tissue) and bony tissue (coefficient of meatiness), muscular tissue and bony tissue, muscular tissue and fat tissue. To determine age effect on results obtained, data obtained were grouped according to age of rams: 1st group – rams up to 300 days of age, 2nd group – rams above 300 days of age.

Data mathematical processing is done using analysis of dispersion, correlation and variation. Interrelation of traits is determined with the aim to explain effect of particular traits on the quality of carcass. Coefficient of variation is used to reflect obtained data dispersion around

average indices.

Data are processed using Microsoft Excel for Windows 2000 [Arhipova, Bāliņa, 1999] and SPSS 8.0 program package [Arhipova, Bāliņa, 2003; Backhaus et al., 2000].

Significance of difference in traits is designated using 2 levels of significance: * $p < 0.05$ and ** $p < 0.01$.

^{ab} means, that average indices in the same line with different superscripts are significantly different at the level of significance - * $p < 0.05$.

Research results and discussion. When characterizing sampled population, we used the following traits: age and live weight prior to slaughter, carcass weight and slaughter result (see Table 1).

Table 1. Slaughter result

No.	Age before slaughter, days	Live weight before slaughter, kg	Slaughter weight, kg	Slaughter result, %
1.	277	41	19.5	47.5
2.	318	45	21.0	46.6
3.	193	38	18.0	47.3
4.	258	40	20.0	50.0
5.	308	41	19.0	46.3
6.	322	43	21.0	48.8
7.	318	47	23.0	48.9
8.	363	53	26.0	49.1
9.	360	55	28.0	50.9
10.	360	50	24.5	49.0
\bar{x}	308	45.3	22.0	48.5
S	53.2	5.8	3.2	1.5
S %	17.3	12.8	14.9	3.0

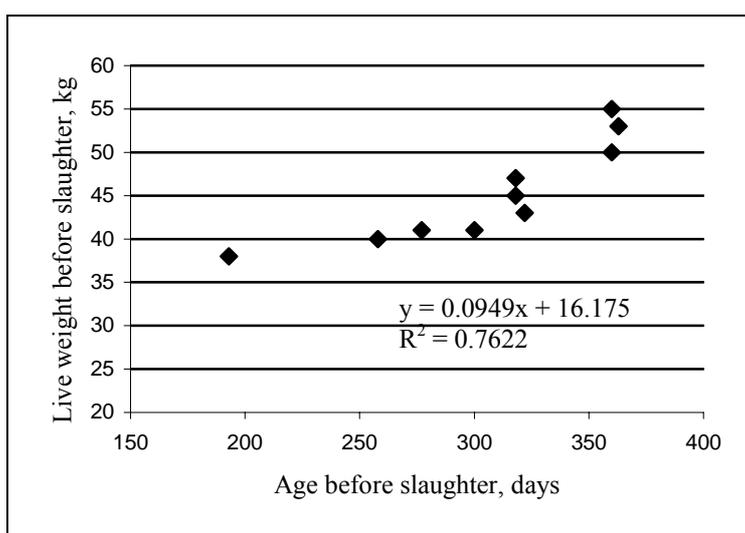


Figure 1. Effect of age on live weight of rams prior to slaughter

The average age of rams prior to slaughter was 308 days or 10 months and the reached average live weight was 45.3 kg being similar to results obtained in Lithuania where experiments with Lithuanian whitehead sheep were conducted, and where the average live weight of lambs

slaughtered at the age of 10-12 months is 40.8 kg [Zapasnikiene, 2002]. The average slaughter result of LD rams used in research was 48.5%. It is in agreement with findings documented in the scientific literature [Norvele, 1998; Volgājeva, 1999; Kairiša, 2005], but in mutton type

sheep slaughter result may reach 50.0% - 55.0% [Ernst, Kalm, 1994].

Coefficient of variation for live weight of rams prior to slaughter was of mean value (12.8%) indicating that group of rams intended for slaughter is corrected. Coefficient of variation for age prior to slaughter (17.3 %) indicate that desirable live weight prior to slaughter is reached at different age, which could be explained by individual traits in animals.

In sampled population, the age of rams prior to

slaughter varied from 193 to 363 days and with this we had to find our weather the age prior to slaughter had an effect on animal live weight and quality of carcass (see Figure 1).

The obtained linear regression curve indicates that age increase results in live weight increase in rams intended for slaughter. We concluded that rams up to one year of age continued to grow but does age effect meat productivity and carcass quality in rams (see Table 2).

Table 2. Slaughter indices in LD rams of different age

Indices, units		Age group			
		1st group (up to 300 days)		2nd group (above 300 days)	
		x	± S	x	± S
Average age before slaughter, days		257 ^a	±46.0	340 ^b	±22.9
Live weight, kg		40.0 ^a	±1.41	48.8 ^b	±4.67
Carcass weight, kg		19.1 ^a	±0.85	23.9 ^b	±2.80
Carcass right half weight, kg		9.4 ^a	±0.47	11.6 ^b	±1.37
Analysis of carcass right half weight					
Muscular tissue	kg	5.0 ^a	±0.30	6.8 ^b	±0.92
	%	53.6 ^a	±0.83	58.1 ^b	±2.63
Fat tissue	kg	1.8	±0.23	2.2	±0.32
	%	19.2	±1.87	18.5	±1.84
Bony tissue	kg	2.3	±0.12	2.4	±0.27
	%	24.1 ^a	±1.90	20.5 ^b	±0.71

^{a,b} Correlation is significant at the 0.05 level

Results summarized in Table 2 indicate that rams of the 1st group were by 65 days or two months younger and, with this, with significantly smaller live weight prior to slaughter (-8.8), obtained carcass weight (-4.8) and carcass right half weight (-2.2). Results of carcass tissue analysis give evidence that only muscular tissue weight and percentage in carcass were significantly lower, -1.8 kg and -4.5%, respectively. Significant differences in other tissue groups were not observed. Insignificant was difference in bony tissue weight, but still with significant percentage in carcass, and significantly lower in ram carcass of the 2nd group. We can conclude that 10 months was the time of intensive bone formation. It cannot be stated regarding muscular tissue and fat tissue formation,

as both indices mentioned were higher for older animals.

Further we cleared up weather relationship between tissue in carcass were effected by the slaughtered animal age (see Table 3). Averagely, the meat to bony tissue ratio was 3.5 in the slaughtered ram carcass, but it was only 3.0 in carcass obtained from rams at the age of up to 300 days thus indicating to lower meat and higher bone proportion in carcass. Significantly higher meat to bone ratio was obtained in carcass of rams slaughtered at the age of above 300 days. So with the increase of animal age the meat to bone ratio increases. Our research results are in agreement with those already published in Latvia [Norvele, 1999].

Table 3. Relationship between carcass tissue in LD rams of different age

Indices	Relationship								
	n	Average, in whole group	± S	n	1st group (up to 300 days of age)	± S	n	2nd group (above 300 days of age)	± S
Meat to bony tissue ratio	10	3.5:1	± 0.43	4	3.0 ^a	± 0.30	6	3.7 ^b	± 0.18
Muscular tissue to bony tissue ratio	10	2.6:1	± 0.36	4	2.2 ^a	± 0.18	6	2.8 ^b	± 0.21
Muscular tissue to fat tissue ratio	10	3.0:1	± 0.41	4	2.8	± 0.28	6	3.2	± 0.44

^{a,b} Correlation is significant at the 0.05 level

Similar tendency was observed for the muscular tissue to bony tissue ratio in carcass being 2.6 on the average in all the group of slaughtered rams, and 2.2 in carcass obtained from rams slaughtered at the age of up to 300 days. It could be explained by a smaller amount of muscular tissue in carcass.

The muscular tissue to fat tissue ratio in all slaughtered animal group accounted 3.0 on the average, in 1st group – 2.8, in 2nd group – 3.2. In this trait, significant differences were not observed. Research findings have proved that higher muscular tissue to fat tissue ratio has been obtained with heavier lamb carcass weight [Kairiša, 2005].

According to EUROP standard used in sheep carcass classification, assessment of muscular tissue development in slaughtered LD ram carcass in 50% cases corresponded

to class R and in 50% cases to class O. Assessment of fat tissue stratification was 3 in 70.0% cases and 4 in 30.0% cases. It indicates on medium muscular tissue development and too high fat tissue stratification in carcass. Latvian researchers have the task to conduct experiments with the aim of improving quality of carcass obtained from LD rams. Results of research with Estonian whitehead sheep in 2005 were similar to ours, in 53.7% cases muscular tissue assessment in lamb carcass correspond to class R, but assessment of fat tissue stratification indicates that in 65.1% cases it is above 2 [Piirsalu, 2005; Piirsalu, 2003].

To clear up interrelation between separate slaughter indices, correlation between them was calculated (see Table 4).

Table 4. Mutual relationship between slaughter traits in rams of LD breed

Indices	Age before slaughter, days	Live weight before slaughter, kg	Proportion of muscular tissue, %	Proportion of fat tissue, %	Assessment of muscular tissue development by EUROP standard	Fat tissue class
Age before slaughter, days	1	0.862(**)	0.688(*)	0.052	-0.402	0.108
	-	0.001	0.028	0.887	0.250	0.767
Live weight before slaughter, kg	0.862(**)	1	0.697(*)	-0.158	-0.273	-0.274
	0.001	-	0.025	0.663	0.446	0.444
Proportion of muscular tissue, %	0.688(*)	0.697(*)	1	-0.563	-0.759(*)	-0.288
	0.028	0.025	-	0.090	0.011	0.420
Proportion of fat tissue, %	0.052	-0.158	-0.563	1	0.642(*)	0.684(*)
	0.887	0.663	0.090	-	0.045	0.029
Assessment of muscular tissue development by EUROP standard	-0.402	-0.273	-0.759(*)	0.642(*)	1	0.218
	0.250	0.446	0.011	0.045	-	0.545
Fat tissue class	0.108	-0.274	-0.288	0.684(*)	0.218	1
	0.767	0.444	0.420	0.029	0.545	-

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

In research it is cleared up that the age of LD breed rams before slaughter had significant influence on animal live weight before slaughter as well as on the weight of muscular tissue and fat tissue in carcass. So when slaughtering rams from 6 months to one year of age, the weight of muscular tissue and fat tissue in carcass increase.

When analyzing carcass quality by the EU standard, significant negative correlation is observed between assessment of muscular tissue development and proportion of muscular tissue in carcass. It could be due to applied methods, where lower numerical value shows better development of muscular tissue and with this higher proportion in carcass. Close positive relationship

has been observed for assessment and proportion of fat tissue in carcass. A tendency is observed that carcass with greater muscular tissue weight has higher assessment of muscular tissue development. Negative correlation is established between fat tissue class and muscular tissue assessment, which indicates that increased value of one trait results in decreased value of a second trait.

Conclusions

1. Research results suggest, that the age of Latvian darkhead rams prior to slaughter had significant effect on live weight of animals as well as on muscular tissue and fat tissue weight in carcass. So when slaughtering rams from 6 months to one year of age, the weight of muscular tissue and fat tissue increased.

2. Rams up to 300 days of age had significantly smaller live weight prior to slaughter (-8.8), obtained carcass weight (-4.8) and carcass right halves weight (-2.2). Results of carcass tissue analysis give evidence that only muscular tissue weight and percentage in carcass was significantly lower - 1.8 kg and -4.5% respectively. In other tissue groups, significant differences were not observed. Insignificant were difference in bony tissue weight yet significant percentage in carcass. And significantly lower in carcass of rams of the 2nd group.

3. In slaughtered LD ram carcass the meat to bony tissue ratio was 3.5, but it was only 3.0 in carcass obtained from rams up to 300 days of age thus indicating on lower meat proportion and higher bone proportion in carcass. Significantly higher meat to bone ratio was obtained in carcass of rams above 300 days of age. So the meat to bone ratio increased with the increase of age. Similar tendency was observed for the muscular tissue to bony tissue ratio in carcass, where it was 2.6 on the average in the whole group of slaughtered rams, but it was 2.2 in carcass obtained from rams up to 300 days of age and could be due to smaller amount of muscular tissue in carcass.

4. Significant negative close correlation is established between assessment of muscular tissue development and proportion of muscular tissue in carcass. Close positive correlation is observed between assessment and proportion of fat tissue in carcass. There is a tendency observed that carcass with higher muscular tissue weight has higher assessment of muscular tissue development. There is negative correlation between assessment of fat tissue class and muscular tissue assessment, which indicates, that the increase in value of one trait results in decreased value in other trait.

Literature

- Abeyene H.E. (1998) Major National and International trends in sheep breeding // Sheep and goat production in Central and Eastern European Countries. Proceedings of the workshop held in Budapest, Hungary. Rome, p. 43-50
- Arhipova I., Bāliņa S. (1999) Statistika ar Microsoft Excel ikvienam1., 2.daļa. Rīga, Datorzinību Centrs, 163.; 136 lpp.
- Arhipova I., Bāliņa S. (2003) Staistika ekonomikā. Risinājumi ar SPSS un Microsoft Excel. Rīga, Datorzinību Centrs, 349 lpp.
- Backhaus K. et al., (2000) Multivariate Analisenmethoden. Eine anwendungsorientierte Einführung. 9.Aufb. - Berlin: Springer.- s. 661
- Ciltsdarba normatīvie dokumenti (2004) // 4.sējums. Latvijas Republikas Zemkopības ministrija. - Rīga, 165-170. lpp.
- Commission Regulation (EEC) No 461/93 of 26 February 1993 laying down detailed rules for the Community scale for the classification of carcasses of ovine animals.
- Commission Regulation (EEC) No 461/93 of 23 July 1992 concerning the Community scale for the classification of carcasses of ovine animals and determining the Community standard quality fresh or chilled sheep carcasses and extending Regulation (EEC) No 338/91.
- Ernst E., Kalm E. (1994) Grundlagen der Tierhaltung und Tierzucht. Verlag Paul Parey, Hamburg, s. 212.-217.; 258.-260.
- Hartjen P. (1991) Schätzung der Gewebezusammensetzung beim Rind mit Hilfe von Ultraschallmessungen und Schlachtkörpermerkmalen / Dissertation, FB Agrarwissenschaften, Kiel. s. 18-99
- Javor A., Kukovics S., Nabradi A., Molnar Gy., Molnar B., Molnar A. and Abraham M. (1998) Present stane of Hungarian sheep breeding // Sheep and goat production in Central and Eastern European countries. Proceedings of the workshop held in Budapest, Hungary. Rome, p.107-120
- Kairiša D., Sprūžs J. (2005) Jēru liemeņu kvalitāte - viens no galvenajiem gaļas ražošanas rādītājiem aitkoptībā. // LLU Raksti 13 (308) 55-60. lpp.
- Kairiša D. (2005) Kvalitatīvas jēru gaļas ieguves zinātniskais pamatojums Latvijā. // Promocijas darbs. Jelgava, 132 lpp.
- Latvijas Valsts standarts (2000) Aitu liemeņa klasifikācija LVS 298:2000. 7 lpp.
- Norvele G. (1998) Sheep and goat breeding in Latvia // Sheep and goat production Central and Eastern European countries. Proceedings of the workshop held in Budapest, Hungary. Rome, p.120. 122
- Norvele G. (1999) Ātraudzības un gaļas īpašību uzlabošana Latvijas Tumšgalves aitām, pielietojot krustošanā Il-de-France, Vācijas melngalves un Tekselas šķirnes vaislas materiālu // Latvijas lauksaimniecības zinātniskie pamati. Latvijas Lauksaimniecības universitāte; 16.52-16.55. lpp.
- Pārraudzības gada rezultāti 2005 (2006) / LRZM VCIDAC. R.: SIA "Madonas poligrāfists, 8.-31. lpp.
- Piirsalu P. (2003) The quality of meat from the carcasses of Estonian breeds of cheep classified according to the EUROP grading system // Proceedings of the 9th Baltic animal breeding conference. Sigulda. p. 115-120
- Piirsalu P., Mettis K. (2005) Factors affecting sheep meat quality of the Estonian whiteface breed of sheep classified according to the SEUROP grading system // Proceedings of the 11th Baltic animal breeding conference. Palanga. p. 137-140
- U.S.D.A. (1960) Consumer and Marketing Sevice / Official United States Standart for grades of Slaughter Lambs, Yearlings and Sheep. S.R.A.-C. and M. p.168
- Volgajeva J. (1999) Latvijas Tumšgalves šķirnes gaļas produktivitātes izkopšana, izmantojot radnieciskās šķirnes // Latvijas lauksaimniecības zinātniskie pamati. Latvijas Lauksaimniecības universitāte. 16.48-16.52. lpp.
- Zapasnikiene B. (2002). The influence of season and frequency of lambing on fertility and progeny weight of Lithuania local coarsewooled sheep. // Proceeding of the 7th Baltic Animal Breeding Conference, Tartu. p. 188.-191.
- Zinātnes un tehnoloģija vārdnīca (2001) Galvenā redaktore D.Guļevska (autoru kolektīvs) Apgāds "Norden AB" 754 lpp.