Agronomy Research **16**(S2), 1527–1533, 2018
https://doi.org/10.15159/AR.18.090

Meat chemical composition of pasture pure lambs and crossbreeds

J. Vecvagars, D. Bārzdiņa and D. Kairiša*

Latvia University of Life Sciences and Technologies, Faculty of Agriculture, Institute of Agrobiotechnology, Liela street 2, LV – 3001 Jelgava, Latvia
*Correspondence: daina.kairisa@llu.lv

Abstract. Increased customer interest of safe, healthy and environmentally friendly food consumption promote development of sheep farming industry in Latvia. Aim of the paper – explain of different pasture-fattened sheep breed and their crosses lamb meat composition traits. A study of pasture fattened lamb meat chemical composition was carried out from year 2013 to 2017. Fattening lambs were kept in breeding rams control station 'Klimpas' (57°50'58.8''N 25°19'39.6''E) pasture array. Lambs were slaughtered in a certified slaughterhouse, but analysis of meat chemical composition were conducted in laboratory of Institute of Food Safety, Animal Health and Environment (BIOR). For the analysis of the meat chemical composition were used up to 1 kg heavy *Quadriceps femoris* muscle samples. In meat were analysed following elements of its chemical composition: dry matter, protein, fat, minerals, pH, cholesterol and unsaturated fatty acids. Data analysis shows that the lambs before slaughter ranged in age from 5 to 8 months. Lamb meat obtained from the study groups had a significantly different total amount of dry matter and fat. The lowest total fat, but the highest ash content was obtained in the lamb meat of the extensive breed group. The lowest total fat and the highest ash content were obtained in the lamb meat from the extensive breed group. In meat obtained a small (in individual samples < 0.10%) cis-10-pentadecenoic acid, cis-11-eicosenoic acid and myristoleic acid content. Of unsaturated fatty acids in lamb meat were represented higher amount of oleic acid, linoleic acid and elaidic acid.

Key words: breeds, lamb, pasture, meat, composition.

INTRODUCTION

Rapidly growing consumers interest of safe and healthy food in their diet are encouraging development of sheep husbandry. In particular, this refers to the products of animal origin derived in environmentally friendly farming conditions.

Feeding ruminants with grass-based feed provides cheap and high quality production.

In suckling period lamb diet main nutrients provides milk, after weaning different feedstuffs, for example, meadow hay and concentrates (Scerra, et al., 2007).

Research studies in different animal species meat composition were repeated by Strazdiņa (2014); less studied was the chemical composition of small ruminants.

Latvia Darkhead and crossbreed lamb fattening results in 2005 showed that 10 month old lambs meat contain 25.7% dry matter and in dry matter were 18% protein, 6.6% fat and 1.3% ash (Kairiša, 2005).

Studies of sheep meat chemical composition and its influencing factors are important for farmers and consumers.

It is common practice to make crossbreed lambs by using local breed sheep and different meat type breeds to improve their adaptation to different environmental conditions.

The main focus of scientists in context of meat composition and quality is concerning their age and sex, various feedstuffs and the influence of lamb fattening technologies on their meet quality (Tejeda et al., 2008; Abdullah et al., 2009; Jandasek, 2013).

The aim of study – explain meat chemical composition of pasture fattened pure breed and crossbreed lambs.

MATERIALS AND METHODS

Study was carried out from 2014 to 2017 in Jeri parish, Rujiena region, Latvia. Lambs were kept in pasture all day in one group with unlimited access to hay, mineral licks and water.

Hay contained 869.5 g kg^{-1} of consumed dry matter with 96.6 g kg^{-1} crude protein and 9.72 MJ kg^{-1} metabolizable energy.

Quality of pasture grass varied depending of month. Dry matter in 1 kg grass were in range from 177 g on May to 205.8 g on September, protein in 1 kg dry matter were from 134.9 g on September to 162.5 g on May. Good quality high yielding grass fodder contained, high quality botanical composition and good chemical composition. Grass productivity depends on various factors suchas climate, soil, botanical composition, country and grazing patterns (Priolo et al., 2002; Beyene & Mlambo, 2011; El-Shesheny et al., 2014).

Lamb meat samples used in of Latvia Darkhead, four meat type breeds and most popular crossbreeds among Latvia sheep breeders (Table 1).

Table 1. Study materials

Trial group	Breed (abbreviation)	Number of meat samples
Local sheep breed	Latvia Darkhead (LT)	5
Meat type sheep breeds	Charollais (SA)	4
	Ile de France (IF)	3
	German Merino Local (VMV)	4
	Oxforddown (OX)	5
Latvia Darkhead × meat type sheep crossbreeds	LT × T (Texel)	4
	LT × S (Suffolk)	6
	LT × VMV	5
	LT × Dorper (DOR)	3

Lambs were slaughtered in certified slaughterhouse when reached 40 kg body weight. Analysis of meat chemical composition tested in science centre BIOR laboratory. *Quadriceps femoris* muscles samples were used for chemical content

analysis. In meat established various nutrients: moisture (%), protein (%), crude fat (%), ash (%), pH, cholesterol (mg g^{-1}) and several unsaturated fatty acids (Table 2).

Table 2. The used methods in meat chemical analysis

Meat chemical composition, %	Methods
Moisture	LVS ISO 1442:1997
Protein	LVS ISO 937:1998
Crude fat	LVS ISO 1443:1973
Ash	ISO 936:1998
Cholesterol	BIOR-T-012-132-2011*
Unsaturated fatty acids, %	
Alpha-linolenic acid [C18:3 n3]	BIOR-T-012-131-2011** (fatty acid composition in fats)
Arachidonic acid [C20:4 n6]	
Linolenic acid [C18:2 n6c]	
Oleic acid [C18:1 n9c]	
Palmitoleic acid [C16:1 n9c]	

* Method of gas chromatography; analysed choresterol composition in sample; ** Accredited method of gas chromatography; analysed fatty acid composition in fats.

Data of study was analysed by using mathematical methods. Data obtained from analysis in laboratory were converted to g kg^{-1}. We calculated trait values – mean, standard error and coefficient of variation. Significantly difference between mean values determined by *t*-test and signed with lowercase Latin letters a, b, c ($P \leq 0.05$), also calculated correlation of results.

RESULTS AND DISCUSSION

Average age of lambs before slaughtering was 191 days or little more than 6 months. In meat samples in average 730.2 g kg^{-1} were water, 195.6 g kg^{-1} protein, 67.3 g kg^{-1} crude fat and 10.5 g kg^{-1} ash (Table 3). The chemical composition of Polish Lowlands breed lamb meat samples (taken from *Musculus adductor)* was similar that the present study, it contained 25.55% dry matter, 19.28% protein, 4.15% fat and 1.05% ash (Niedziółka & Pieniak-Lendzion, 2006). Similar nutrient composition in different region lamb meat was shows a similarity of lamb fattening technologies.

Table 3. Meat chemical composition (g kg^{-1}) and pH value in different sheep breed feeding with pasture grass

Trait	LT	SA	IF	OX	VMV
	mean ± standard error				
Age, days	211 ± 12.0	175 ± 17.5	186 ± 14.5	199 ± 12.1	192 ± 4.5
Water, g kg^{-1}	721.4 ± 7.5	753.5 ± 7.1	740.3 ± 9.3	709.2 ± 23.9	728.3 ± 20.8
Dry matter, g kg^{-1}	278.4 ± 7.8	246.5 ± 7.1	259.7 ± 9.3	292.0 ± 24.3	274.3 ± 20
Protein, g kg^{-1}	194.0 ± 3	200.5 ± 2.5	206.0 ± 1.2	195.0 ± 6.6	193.3 ± 3.4
Crude fat, g kg^{-1}	75.6 ± 9.1^{a}	38.3 ± 9.7^{b}	45.7 ± 11.7^{a}	87.4 ± 30.8^{a}	73.3 ± 23.6^{a}
Ash, g kg^{-1}	10.4 ± 0	11.3 ± 0.2	11.1 ± 0.2	10.1 ± 0.4	10.3 ± 0.3
pH, at 20°C	5.70 ± 0.1	5.67 ± 0.	5.77 ± 0.1	5.75 ± 0.1	5.72 ± 0.1
Cholesterol, mg 100 g^{-1}	88.0 ± 10.4^{a}	63.7 ± 5.4^{b}	61.4 ± 3.8^{b}	77.0 ± 12.5^{ab}	88.8 ± 15.5^{ab}

$^{a, b}$ – different letter represent significantly different between meat traits results ($P \leq 0.05$); LT – Latvia Darkhead; SA – Charollais; IF – Il de France; OX – Oxforddown; VMV – German Merino Local.

Age of lambs before slaughtering was in range from 175 days or 5.5 months for Charollais lambs up to 211 days (7 months) for Latvia Darkhead lambs. In end of fattening were recorded large age difference of SA lambs. Age difference of age between SA and LT group lambs was 36 days which did not different significantly.

The maximal protein (206.0 g kg^{-1} IF, 200.5 g kg^{-1} SA) and minimal crude fat (45.7 g kg^{-1} IF and 38.3 g kg^{-1} SA) content in meat were obtained from France origin sheep breeds (Table 4).

Table 4. Chemical content and pH value of crossbreed lamb meat samples

Traits	LT × T	LT × S	LT × DOR	LT × VMV
	mean ± standard error			
Age, days	192 ± 9.8	196 ± 5.7	170 ± 10.7	201 ± 9.1
Water, g kg^{-1}	736.0 ± 16	738.5 ± 14.9	703.3 ± 30.6	730.80 ± 12.5
Dry matter, g kg^{-1}	276.0 ± 12.3	262.5 ± 14.6	296.7 ± 30.5	272.9 ± 12.5
Protein, g kg^{-1}	188.0 ± 2.7	192.8 ± 3.1	190.0 ± 7.8	199.6 ± 5.5
Crude fat, g kg^{-1}	78.5 ± 10.1	60.2 ± 16.4	97.7 ± 38.2	65.2 ± 16.7
Ash, g kg^{-1}	10.0 ± 0.2	10.2 ± 0.3	10.7 ± 0.4	10.5 ± 0.3
pH, at 20°C	5.82 ± 0	5.76 ± 0	5.69 ± 0	5.94 ± 1.6
Cholesterol, mg 100 g^{-1}	66.0 ± 5.6[a]	75.8 ± 8.2[ac]	53.2 ± 4.3[b]	89.5 ± 7[c]

[a, b, c] – Different letter represent significantly differences between meat traits results ($P \leq 0.05$).

Less protein was from LT and VMV lamb meat samples 193.3–194 g. SA and IF lamb meat contained 63.7 mg g^{-1} and 61.4 mg g^{-1}. In a study where used the father breeds as Oxforddown, Texel, Charollais or Suffolk, but as a mother breed German Merino Local in meat had significantly different pH values, protein amount and meat juiciness post mortem 24 hours and 48 hours ($P < 0.05$). Charollais × German Merino Local crossbreed lamb meat had the best quality, meat contained more protein, intramuscular fats, less juice loss and better juiciness and texture (Jandasek et al., 2013).

The amount of cholesterol in different animal meat compared with other food products was low, because it correlated to amount of muscle fibre and its composition. In comparison hen eggs may containe 380 mg g^{-1} and beef, pork and lamb meat 60–70 mg 100 g^{-1} cholesterol (Chizzolini et al., 1999). The youngest lamb in the present study were LT × DOR crossbreed, lamb meat had increased fat and decreased cholesterol (53.2 g mg^{-1}) amount, meat had pH 5.59 as an average.

The pH value of lamb meat varied from 5.5 to 5.9 in an average, 3–4 month of age. Chilled meat from heaviest lambs (19–24 kg body weight) had bigger pH value compared to smaller lambs ($P < 0.01$). Heaviest carcass meat has a stronger taste and aroma (Teixeira et al., 2005).

Most meat food have similar ratio of saturated to unsaturated fatty acid amount, but ruminant meat contained less polyunsaturated fatty acids. Stearic acid (30% of saturated acid amount) have neutral effect to plasma cholesterol synthesis (Bonanome & Grundy, 1988).

The studied meat samples contained 495 g kg^{-1} to 580 g kg^{-1} of unsaturated fatty acids (Table 5).

Table 5. Unsaturated fatty acid amount in purebreds lamb meat samples, g

Unsaturated fatty acid	LT	SA	IF	OX	VMV
	mean ± standard error				
C18:1 n9c	369.5 ± 11.3	347.0 ± 13.2	397.3 ± 26.1	386.8 ± 14.5	360.0 ± 24.5
C18:2 n6c	33.5 ± 3.5^{a}	57.0 ± 10^{ab}	49.7 ± 3^{b}	36.6 ± 4.9^{ab}	36.5 ± 4.5^{ab}
C18:3 n3	11.9 ± 1.9^{a}	24.8 ± 4.2^{b}	21.0 ± 6.7^{ab}	17.0 ± 2.4^{ab}	15.8 ± 1.2^{ab}
C16:1 n9c	17.7 ± 2.6	13.0 ± 1.2	14.7 ± 2.7	17.4 ± 0.9	15.3 ± 3.4
C20:4 n6	2.9 ± 0.1	8.0 ± 3.8	5.7 ± 1.5	5.0 ± 1.6	5.0 ± 2.1

$^{a, b}$ – Different letter represent significantly differences between unsaturated fatty acid traits results ($P \leq 0.05$).

From unsaturated fatty acids profile biggest part of lamb fat took oleic acid [C18:1 n9c] (from 347 g kg^{-1} SA lambs to 397.3 g kg^{-1} IF lambs). Similar results were obtained in Ricardo et al. (2015) and Santos-Silva et al. (2002) studies. In lamb fat linolenic acid [C18:2 n6c] took largest part of omega 6 fatty acids, for example, in SA lamb fat linoleic acid was 57.0 g kg^{-1}, but in LT lamb fats less 33.5 g kg^{-1}.

LT 11.9 g kg^{-1} and SA 24.8 g kg^{-1} breed lamb fat contained significantly different amount of alpha-linolenic acid [C18:3 n3] ($P < 0.05$).

Fatty acid profile between purebreds and crossbreed lamb fat was similar (Table 6).

Table 6. Fatty acids composition (percentage of total fatty acids) of intramuscular fat (m. *Longissimus dorsi*) from lambs fed with grass

Fatty acids	LT × T	LT × S	LT × DOR	LT × VMV
	mean ± standard error			
C18:1 n9c	405.0 ± 4.6^{a}	369.8 ± 15^{b}	377.0 ± 8^{b}	356.8 ± 16.6^{b}
C18:2 n6c	36.3 ± 3.5	40.3 ± 2.9	41.3 ± 3	33.0 ± 2.5
C18:3 n3	16.3 ± 5	17.8 ± 2.5	25.0 ± 3	16.7 ± 2.7
C16:1 n9c	21.3 ± 3.6	16.3 ± 1.4	15.0 ± 0	16.6 ± 2.5
C20:4 n6	2.7 ± 0.9	4.4 ± 0.9	4.0 ± 1.5	5.0 ± 2

$^{a, b}$ – Different letter represent significantly differences between unsaturated fatty acid results ($P \leq 0.05$).

The amount of unsaturated acids do not significantly different between breeds, only LT × T crossbreed lamb meat contained more oleic acid 405 g kg^{-1}.

Correlation coefficients among meat chemical composition (Table 7) show that meat moisture was related to protein (r = -0.61), crude fat (r = -0.96) and ash (r = 0.62).

Positive correlation was found between protein, protein to ash (r = 0.71), but negative correlation between protein and crude fat (r = 0.72).

Correlations between cholesterol and unsaturated fatty acids were negative and moderate by related, for example cholesterol to alpha-linoleic acid (r = -0.45), cholesterol to linoleic acid (r = -0.48) and positive related choresterol content were to palmitolenic acid (r = 0.39).

Correlations of unsaturated fatty acids are moderate-close related (Table 8). Ratio alpha-linolenic acid to arachidonic acid had moderately positive correlation (r = 0.47), correlation to linoleic acid (r = 0.77), but alpha-linolenic to palmitoleinic acid had negative correlation (r = -0.48).

Table 7. Correlations of meat chemical composition and unsaturated fatty in sheep meat, feeding in pastures

Trait	Moisture	Protein	Crude fat	Ash	Cholesterol	pH
Protein	0.61*	1.00				
Crude fat	-0.96*	-0.77*	1.00			
Ash	0.62*	0.71*	-0.72*	1.00		
Cholesterol	-0.02	0.02	0.03	-0.15	1.00	
pH	0.01	-0.27	0.07	-0.16	-0.10	1.00
Alpha-linoleic acid [C18:3 n3]	0.05	0.14	-0.14	0.16	-0.45*	-0.05
Arachidonic acid [C20:4 n6]	0.11	-0.01	-0.13	0.06	-0.05	-0.20
Linolenic acid [C18:2 n6c]	0.24	0.10	-0.27	0.21	-0.48*	-0.03
Oleic acid[C18:1 n9c]	-0.21	-0.05	0.19	-0.20	-0.28	-0.01
Palmitoleic acid[C16:1 n9c]	-0.12	-0.15	0.20	-0.27	0.39*	-0.19

* – significant difference ($P < 0.05$).

Table 8. Correlations amount of unsaturated fatty acids

Trait	Alpha-linoleic acid [C18:3 n3]	Arachidonic acid [C20:4 n6]	Linolenic acid [C18:2 n6c]	Oleic acid [C18:1 n9c]
Arachidonic acid [C20:4 n6]	0.47*	1.00		
Linoleic acid [C18:2 n6c]	0.77*	0.80*	1.00	
Oleic acid [C18:1 n9c]	-0.07	-0.07	0.07	1.00
Palmitolenic acid [C16:1 n9c]	-0.48*	-0.18	-0.44*	0.44*

* – significantly difference ($P < 0.05$).

Arachidonic acid obtained a close positive correlation with linoleic acid, but linolenic acid have moderate positive collation with palimitolenic acid (r = -0.44). Although the highest proportion of unsaturated fatty acids is for oleic acid, it had positive correlation to palmitoleinic acid (r = 0.44).

CONCLUSIONS

The results of lamb meat nutrient amount proved that pasture fattened crossbreed lambs have meat with lowest fat and cholesterol amount and highest amount of omega 3 and omega 6 fatty acids.

Omega 3 and omega 6 fatty acids had a positive correlation, but omega 3 to omega 9 fatty acids – negative.

Pasture-based lamb fattening provides good lamb meat production, best precocity was recorded from lambs with France origin - Charollais and Il de France.

Meat type ram crossbreeding with local breed ewes had a positive effect on amount of nutrient and unsaturated fatty acids in crossbreed lamb meat.

ACKNOWLEDGEMENTS. Latvia Republic Ministry of Agriculture founded study 'Different sheep breed and their crossbreed suitability to quality carcass and lamb meat production'.

REFERENCES

Abdullah, A. & Qudsieh, R. 2009. Effect of slaughter weight and time on the quality of meat from Awassi ram lambs. *Meat Science* **82**, 309–316.

Beyene, S.T. & Mlambo, V. 2011. Botanical and chemical composition of common grass species around dip–tank areas in semi–arid communal rangelands of swaziland. *Tropical and Subtropical Agroecosystems* **14**, 1–10.

Bonanome, A. & Grundy, S.M. 1988. Effect of dietary stearic acid on plasma cholesterol and lipoprotein levels. *New England Journal of Medicine* **318**, 1244–1248.

Chizzolini, R., Zanardi, E. & Derigoni, V. 1999. Calorific value and cholesterol content of normal and low-fat meat and meat products. *Trends in Food Science and Technology* **10**, 119–128.

El-Shesheny, M.A., Hendawy, S.H. & Ahmed, K.M. 2014. Assessment of productivity, botanical composition and nutritive value of some plant communities at Sidi-Barrani in North Western Coast of Egypt. *Annals of Agricultural Science* **59**(2), 155–163.

Jandasek, J., Milersik, M. & Lichovnikova, M. 2013. Effect of sire breed on physio-chemical and sensory characteristics of lamb meat. *Meat Science* **96**, 88–93.

Kairiša, D. 2005. Scientifical purposes of lambs meat production in Latvia*:* summary of Doctoral Thesis of Dr. agr. Scientific degree. Jelgava: LLU, 58 pp. (in Latvian).

Niedziółka, R. & Pieniak-Lendzion, K. 2006. Chemical composition of meat (*M. Adductor*) and fatty acids in intramuscular fat of goat kids and ram lambs. *Slovak Journal of Animal Science* **39** (4), 197–200.

Priolo, A., Micola, D., Agabriela, J., Prachea, S. & Dransfieldb, E. 2002. Effect of grass or concentrate feeding systems on lamb carcass and meat quality. *Meat Science* **62**, 179–185.

Ricardo, H.A., Fernandes, A.R.M., Mendes, L.C.N., Oliveira, M.A.G., Protes, V.M., Scatenac, E.M., Roc, R.O., Athaydef, N.B., Girãog, L.V.C. & Alves, L.G.C. 2015. Carcass traits and meat quality differences between a traditional and an intensive production model of market lambs in Brazil: Preliminary investigation. *Small Ruminant Research* **130**, 141–145.

Santos-Silva, J., Bessa, R.J.B. & Santos-Silva, F. 2002. The effect of genotype, feeding system and slaughter weight on the quality of light lambs 2. Fatty acid composition of meat. *Livestock Production Science* **77**, 187–194.

Scerra, M., Caparra, P., Foti, F., Galofaro, V., Sinatra, M.C. & Scerra, V. 2007. Influence of ewe feeding systems on fatty acid composition of suckling lambs *Meat Science* **76**, 390–394.

Strazdiņa, V. 2014. Biochemical evaluation of game meat in Latvia: summary of Doctoral Thesis for the Academic Degree in Engineering and Food Sciences (Dr.sc.ing) Latvia University of Agriculture, 66 pp. (in Latvian).

Teixeira, A., Batista, S., Delfa, R. & Cadavez, V. 2005. Lamb meat quality of two breeds with protected origin designation. Influence of breed, sex and live weight. *Meat Science* **71**, 530–536.

Tejeda, J., Pena, R. & Andres, A. 2008. Effect of live weight and sex on physio chemical and sensorial characteristics of Merino lamb meat. *Meat science* **80**, 1061–1067.