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# FATTY ACID COMPOSITION OF LAMB MEAT AS AFFECTED BY PRODUCTION SYSTEM, WEANING AND SEX

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## ABSTRACT

Fatty acid composition in intramuscular fat of *Longissimus dorsi* (LD) of 32 Jezersko-Solčava lambs was measured in two kinds of production system (grazing on mountain pasture and fattening in stable with hay and cereals ad libitum) and two kinds of weaning system (suckling and weaned) and interaction between them. The effect of sex was also determined. Pasture and stable lambs were slaughtered at average live weight 34 kg. Suckling lambs were slaughtered at 125 days of age (30 kg of live weight) and weaned lambs were slaughtered at 165 days (38 kg of live weight). Lambs on pasture displayed lower percentage of palmitic (C16:0) and oleic (C18:1n-9) and higher percentage of linoleic (C18:2n-6), α-linolenic (C18:3n-3), arachidonic (C20:4n-6) and eicosapentaenoic (C20:5n-3) fatty acids. Pasture lambs had lower percentage of SFA (saturated fatty acids) and MUFA (monounsaturated fatty acids), higher percentage of PUFA (polyunsaturated fatty acids) and especially relatively high percentage of C18:3n-3 (3.3%) in intramuscular fat. Pasture lambs also had higher percentage of n-6 PUFA (15.06%), even 1.5 times higher than stable lambs (9.34%) and consecutively higher n-6/n-3 PUFA ratio (2.1 vs. 1.6). Above all weaning affected MUFA and PUFA. Intramuscular fat of suckling lambs contained less MUFA (34.84% vs. 38.35%) and more PUFA (21.89% vs. 17.08%) as well as higher n-6/n-3 ratio than weaned lambs (1.9 vs. 1.7). The interaction between production system and weaning was statistically significant only for α-linolenic acid, with the highest proportion in LD fat of weaned lambs grazing on pasture (3.48%) and the lowest proportion of weaned lambs fatten in stable (2.71%). Males had lower values of MUFA and higher values of PUFA, n-6 PUFA and n-3 PUFA. The n-6/n-3 PUFA ratio was the same in both sexes (1.8).

Key words: sheep / lambs / meat / fatty acid composition / production systems / weaning / sex

# VPLIV TEHNOLOGIJE REJE, ODSTAVITVE IN SPOLA NA MAŠČOBNO KISLINSKO SESTAVO MESA JAGNJET JEZERSKO-SOLČAVSKE PASME

## IZVLEČEK

V poskus smo vključili 32 jagnjet jezersko-solčavske pasme in primerjali maščobno kislinsko sestavo v intramuskularni maščobi dolge hrbtne mišice (*Longissimus dorsi*) med dvema različnima tehnologijama reje (paša, hlev) ter med sesnimi in odstavljenimi jagnjeti (vpliv odstavitve). V model smo vključili tudi interakcijo med vplivoma tehnologije reje in odstavitve ter vpliv spola. Jagnjeta znotraj različnih tehnologij reje so bila zaklana pri enaki telesni masi (34 kg). Sesna jagnjeta so bila zaklana pri starosti 125 dni (30 kg), odstavljena pa nekoliko kasneje (165 dni starosti in 38 kg telesne mase ob zakolu). V mesu jagnjet, ki so se pasla, je bil manjši delež palmitinske (C16:0) in oleinske (C18:1n-9) kisline in večji delež linolenske (C18:2n-6), α-linolenske (C18:3n-3), arahidonske (C20:4n-6) in eikozapentaenojske (C20:5n-3) kisline. Jagnjeta s paše so imela manj SFA (nasičene maščobne kisline) in MUFA (enkrat nenasičene maščobne kisline) ter več PUFA (večkrat nenasičene maščobne kisline) in še posebej visok delež C18:3n-3 (3,3 %). V primerjavi z jagnjeti, krmljenimi v hlevu, so imela jagnjeta s paše tudi več n-6 PUFA (15,06 %), celo 1,5 krat več kot jagnjeta iz hleva (9,34 %) in zato tudi širše n-6/n-3 razmerje (2,1 oz. 1,6). Odstavitev vpliva predvsem na delež MUFA in PUFA. Meso

sesnih jagnjet je vsebovalo manj MUFA (34,84 % oz. 38,35 %) in več PUFA (21,89 % oz. 17,08 %) in je imelo tudi širše n-6/n-3 razmerje (1,9 oz. 1,7) kot jagnjeta iz hleva. Interakcija tehnologije reje in odstavitve ni bila statistično značilna, razen za α-linolensko kislino. Največji delež te kisline je imelo meso odstavljenih jagnjet s paše (3,48 %) in najmanjši meso odstavljenih jagnjet, krmljenih v hlevu (2,71 %). V intramuskularni maščobi moških jagnjet je bilo manj MUFA in več PUFA, n-6 PUFA in n-3 PUFA. Razmerje n-6/n-3 PUFA je bilo enako pri obeh spolih (1,8).

Ključne besede: ovce / meso / jagnjetina / maščobne kisline / sestava / sistemi reje / odstavitev / spol

## INTRODUCTION

Lambs in Slovenia tend to be reared mainly with their dams on the pasture till they reach 25 to 30 kg, when they are slaughtered. In winter, breeders wean lambs at around 50 to 60 days and fatten them with hay and commercial concentrates or cereals *ad libitum* till they reach 30 to 35 kg. The breeders of autochthonous Jezersko-Solčava breed use four rearing technology difference in weaning system and rearing on pasture or in stable. First is rearing suckling lambs on the pasture and slaughtered them at around 30 kg, second is weaning pasture lambs and continue grazing without any supplementation till they reach 35 kg of live weight. The third system is rearing suckling lambs in stable and slaughtered them at around 30 kg, and the fourth system is fattening weaned lambs with hay and commercial concentrates or cereals *ad libitum* till they reach 35 kg of live weight.

Lambs reared on pasture generally have less subcutaneous fat than stable lambs (Diaz *et al*., 2002; Santos-Silva *et al*., 2002), and less percentage of fat in hindleg (Cividini *et al*., 2007).

However, lamb carcasses and meat quality may vary according to the production system. The most important finding is favourable fatty acid composition of lamb meat rearing on pasture with beneficial effect to human health. The production system influences the lipid content of the meat (Diaz *et al*., 2002; Popova, 2007; Fisher, 2000). Feeding systems can play a significant role in improving meat quality, as the changes in fatty acid composition of body fats are primarily linked to the respective fatty acid contents in the diet. Despite hydrogenation process in the rumen, it has been shown, that pasture feeding increases the concentration of n-3 PUFA fatty acids, compared to grain feeding (Enser *et al*., 1998). Popova (2007) found that lipids of grazing lambs contained relatively more linolenic acid, with a lower C18:2n-6/C18:3n-3 ratio, than the concentrate fed animals.

The aim of the present study was to compare the effect of two production systems (grazing on mountain pasture vs. hay and grain diet) on fatty acid composition of intramuscular fat in LD in lambs of a local Jezersko-Solčava sheep breed. The effect of weaning and sex were also determined to find possible differences in fatty acid composition between sucklings (30 kg live weight) vs. weaned (38 kg live weight) lambs and male vs. female lambs.

## MATERIAL AND METHODS

We select 32 lambs of local Jezersko-Solčava sheep. Half of them (8 males, 8 females) were reared on the mountain pasture (P) at 1 200 m above sea level. The other half (8 males, 8 females) were reared in the stable (S). Lambs were born on the farm and stayed there until slaughter. At the age of 10 days hay and cereals (47% barley, 53% pressed beet pulp) were offered to stable lambs *ad libitum.* Pasture lambs were only grazing, and received no feed supplementation. The contents of pasture grass were 29.07 g/kg crude proteins, 3.05 g/kg crude lipids and 47.81 g/kg crude fibrins. Suckling (SU) lambs (8 stable and 8 pasture lambs) were slaughtered at 125 days of age. The group of weaned (W) lambs were weaned at 125 days of age and fed on with hay and cereals (47% barley, 53% pressed beet pulp) *ad libitum* in the stable

(8 lambs) or were grazing on the pasture (8 lambs) until slaughter. At slaughter, lambs were weighing on the farm before transportation to the experimental abattoir at the Department of Animal Science at Biotechnical Faculty (40 km). All lambs were slaughtered at consecutive dates by the same procedures. After cold storage for 24 h at 4 °C, the LD (100 g) was carefully dissected from the hindpart of loin of each carcass. Samples were vacuum-packed and immediately stored at – 20 °C until analysis.

Total intramuscular fat was determined according to Methodenbuch (1993).

Fatty acid methyl esters (FAMEs) were prepared according to Park and Goins (1994) using *in situ* transesterification (ISTE) method. FAMEs were analysed using a gas chromatograph Agilent 6890 series, equipped with Agilent 7683 series autosampler and FID detector. FAMEs were separated using a capillary column (Varian CP 4720, length 100 m, internal diameter 250 μm, film thickness 0.25 μm). Agilent GC ChemStation was used for data acquisition and processing. Separated FAME-s were identified by retention time comparison and results were calculated using response factors derived from chromatographic standards of known composition (Nu Chek Prep). All analytical results were expressed as percentage (%) mass-fraction of total fatty acids.

The data were analyzed using the mixed procedure of SAS (1990). The model included fixed effects ascribed to production system ($PS_i$), weaning ($W_j$), sex ($S_k$) and production system × weaning interaction. Interaction between weaning and sex and production system and sex were not statistical significant and so excluded from the model.

## RESULTS AND DISSCUSION

Pasture and stable lambs were slaughtered at average live weight 34 kg. Basic statistical data shown that pasture lambs were slightly older (152 days) than stable lambs (137 days). During the rearing period no significant differences in growth (daily gain from birth to slaughter) attributable to the production system, weaning or sex were observed.

Mean slaughter weight for suckling lambs was 29.9 kg (125 days) and for weaning lambs 38.4 kg (165 days). Male and female lambs were slaughtered at the same average live weight (34 kg). Females reached this slaughter weight latter (at 154 days of age) than males (136). Least-squares means for the percentage of the different fatty acids, total saturated, monounsaturated, polyunsaturated, n-6 polyunsaturated and n-3 polyunsaturated (SFA, MUFA, PUFA, n-6 PUFA, n-3 PUFA) fatty acids as well as the ratio between n-6/n-3 in intramuscular fat of LD of lambs raised under different production system, time of weaning and sexes are presented in Table 1.

In intramuscular fat of LD, lambs on pasture displayed lower percentage of palmitic (C16:0) and oleic (C18:1n-9) 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.

Pasture lambs had relatively high percentage of C18:3 n-3 (3.3%) in intramuscular fat of LD, which is higher than those reported by Bas and Morand-Fehr (2000) (1.7% in intramuscular fat and 2.7% in subcutaneous fat) of lambs grazing on pasture. Much lower values of C18:3 n-3 in intramuscular fat of pasture lambs found also Scerra *et al*. (2007) (0.78% pasture lambs vs. 0.51% stable labs). Mostly, we found lower percentage of SFA and MUFA but higher percentage of PUFA in LD of pasture lambs than in stable lambs. Pasture lambs had also high percentage of n-3 PUFA (7.21%) and n-6 PUFA (15.06%), even 1.5 times higher than stable lambs (9.34%). Popova (2007), Fisher (2000), Bas and Morand-Fehr (2000) reported higher percentage of n-6 PUFA in stable lambs fed with cereals or concentrate. Scerra *et al*. (2007) found no significant differences between pasture and stable lambs in content of C18:2 n-6 fatty acid in intramuscular fat, particularly they cited higher values of C18:2 n-6 in both lamb feeding groups, pasture and

stable (14.88% vs. 13.07%) than we reported (9.23% vs. 6.28%). C18:2n-6 is one of the main fatty acid in cereals, consequently it is represented in high contents in meat of ruminants fattening with cereals or concentrates. In our investigation we found opposite results with lower percentage of C18:2 n-6, ARA and consequently n-6 PUFA in intramuscular fat of stable lambs fatten with hay, barley and beet pulp. We attribute these results to good quality of hay (mountain pastureland) and low percentage of C18:2n-6 in beet pulp and barley in comparison with C18:2n-6 content in other cereals according to literature (maize, wheat) (Bas and Morand-Fehr, 2000). Bas and Morand-Fehr (2000) reported that beet pulp decrease the total SFA (palmitic and stearic) in intramuscular fat of lambs.

Table 1. Least-squares means for total intramuscular fat content and fatty acids content (% mass-fraction or g/100g total fatty acid) in LD from lambs differing in production system, weaning and sex

| | Production system (PS) | | | Weaning (W) | | | Sex (S) | | | S.E. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pasture lambs (P) n = 16 | Stable lambs (S) n = 16 | Sig. | Suckling lambs (SU) n = 16 | Weaned lambs (W) n = 16 | Sig. | Male (M) n = 16 | Femal e (FM) n = 16 | Sig. | |
| Intramuscular fat | 2.25 | 3.45 | *** | 2.49 | 3.22 | ** | 2.39 | 3.32 | ** | 0.15 |
| C16:0 | 19.39 | 23.11 | *** | 20.32 | 21.18 | ns | 19.71 | 21.80 | ** | 0.42 |
| C18:0 | 15.81 | 15.04 | ns | 14.84 | 16.00 | ns | 15.91 | 14.93 | ns | 0.47 |
| C18:1 n-9 | 27.84 | 32.43 | ** | 28.27 | 32.00 | ** | 28.37 | 31.90 | ** | 0.81 |
| C18:2 n-6 | 9.23 | 6.28 | *** | 8.75 | 6.76 | ** | 8.71 | 6.80 | ** | 0.37 |
| C18:3 n-3 | 3.27 | 2.88 | ** | 3.05 | 3.09 | ns | 3.31 | 2.83 | ** | 0.11 |
| C20:4 n-6 (ARA) | 4.01 | 1.92 | *** | 3.75 | 2.18 | *** | 3.50 | 2.43 | ** | 0.22 |
| C20:5 n-3 (EPA) | 1.48 | 1.08 | ** | 1.49 | 1.07 | ** | 1.58 | 0.98 | *** | 0.08 |
| SFA | 41.68 | 46.16 | *** | 43.28 | 44.56 | ns | 43.27 | 44.57 | ns | 0.49 |
| MUFA | 35.17 | 38.03 | ** | 34.84 | 38.35 | ** | 34.82 | 38.37 | ** | 0.72 |
| PUFA | 23.14 | 15.82 | *** | 21.89 | 17.08 | ** | 21.91 | 17.05 | ** | 0.88 |
| n-6 PUFA | 15.06 | 9.34 | *** | 14.06 | 10.34 | ** | 13.77 | 10.64 | ** | 060 |
| n-3 PUFA | 7.21 | 5.99 | ** | 7.10 | 6.09 | * | 7.51 | 5.69 | ** | 0.30 |
| n-6/n-3 PUFA | 2.1 | 1.6 | *** | 1.9 | 1.7 | *** | 1.8 | 1.8 | ns | 0.04 |

* = $P \leq 0.05$; ** = $P < 0.01$, *** = $P < 0.001$, ns = $P > 0.05$

Rowe *et al*. (1999) compared fatty acid composition in intramuscular fat of LD in ram lambs slaughtered at 30 kg feeding in stable or grazing on pasture and observed a significant higher content of ARA and lower content of oleic fatty acid in lambs from pasture, which is comparative to our results. Kosulwat *et al*. (2003) reported that fatty acid composition of lamb meat is affected by increase in fatness. They reported that the levels of MUFA, palmitooleic and oleic tended to rise as fatness score increase and levels of C18:2n-6 and C18:3n-3 tended to decrease as fatness score rose. Lower values of C18:2n-6 in stable than in pasture lambs in our experiment may be partly because of higher intramuscular fat content in stable lambs.

One explanation could be in higher biohydrogenation of C18:2n-6 into stearic acid, which is confirmed with very low differences between production systems in percentage of stearic acid. Because higher increase of n-6 PUFA content than n-3 PUFA content in pasture lambs the n-6/n-3 PUFA ratio in the intramuscular fat of pasture lambs was higher than in stable lambs (2.1 vs. 1.6), but still very low and adequate according to the WHO (2003) where n-6/n-3 PUFA ratio is recommended between 4 and 5 in human diet.

In our experiment weaning had most pronounced effect on C18:1 n-9 content, as it increased for almost 4%. Nevertheless, oleic acid predominated in weaned lambs ($P < 0.01$), probably as a result of the potential hydrogenation of the C18 unsaturated fatty acids in the rumen, caused by grass intake at weaned lambs grazing on pasture (Velasco *et al*. 2004). There was no statistical

difference in proportion of C16:0, C18:0, SFA and C18:3n-3 between suckling and weaned lambs. LD muscle fat displayed a greater proportion of linoleic, ARA and EPA acids in suckling lambs. The results demonstrate that lambs which remained with their dams until slaughter presented the lowest proportion of MUFA and the highest proportion of n-6 PUFA, n-3 PUFA and total PUFA, as well as the highest n-6/n-3 ratio. Similarly results reported Velasco *et al*. (2004) with lowest C18:0 and C18:1n-9 in intramuscular and subcutaneous fat of grazing suckling lambs slaughtered at 28 kg in comparison to weaned lambs on pasture.

According to Bas and Morand-Fehr (2000) and Velasco *et al*. (2004), the fatty acid profile of tissues, which reflects the milk feeding period, gradually disappears after weaning. Suckling lambs should presented higher proportions of total saturated fatty acids, especial lauric (C12:0), myristic (C14:0) and palmitic (C16:0) (Velasco *et al*., 2004).

The interaction between production system and weaning was statistical significant only for α-linolenic (C18:3n-3) fatty acid with the highest proportion in LD fat of weaned lambs grazing on pasture (3.48%) and the lowest proportion of weaned lambs fatten in stall (2.71%). Suckling lambs on pasture or in stable reached the same values of C18:3n-3 in LD fat (3.05%).

Significant differences between males and females were observed in intramuscular fat in proportion of C16:0, C18:1n-9 which was higher in females than in males and in C18:2n-6, C18:3n-3, ARA and EPA which were lower in female than in males. The proportion of MUFA was higher in females and the proportion of PUFA, n-6 PUFA and n-3 PUFA were lower in females. The proportion of total SFA was almost the same in both sexes which is contrary to results of Sanudo *et al*. (1998), who reported about more saturated subcutaneous fat in females and no differences between sexes in PUFA. The n-6/n-3 PUFA ratio was the same in both sexes (1.8).

The difference in fatty acid composition between males and females is probably due to higher fatness and content of total intramuscular fat in female animals. Kosulwat *et al*. (2003) found that males tended to have higher levels of PUFA (linoleic and linolenic acid) than females, while females tended to have higher level of MUFA, palmitooleic and oleic acid, which confirms our findings.

## CONCLUSIONS

It is concluded that production system, weaning and sex effected fatty acid composition of intramuscular fat of Jezersko-Solčava sheep breed. Meat from lambs reared on pasture contain less saturated fatty acids, less mono unsaturated fatty acids and higher proportion of polyunsaturated fatty acids especial α-linolenic (C18:3) acid and consecutively more EPA. Weaned lambs in comparison with suckling lambs had more monounsaturated and less polyunsaturated fatty acids. Interaction between PS and W shown significant differences only for α-linolenic (C18:3) fatty acid, with higher proportion of C18:3 in suckling lambs on the pasture. Meat from male lambs contained less monounsaturated fatty acids and more polyunsaturated fatty acids. Generally the n-6/n-3 ratio was found very low (grazing lambs 2.1; stable lambs 1.6; suckling lambs 1.9 and weaned lambs 1.7).

Grazing system can be a good alternative in order to maintain local sheep breeds, which are able to offer good quality products to consumer. Winter fattening lambs in stable with high quality of voluminous forage and supplements like barley and bet pulp can also produce quality meat with adequate fatty acid composition and low n-6/n-3 ratio. Weaning effected fatty acid composition of lamb meat, though suckling (30 kg live weight) as well as weaned (38 kg live weight) lambs offered quality meat with beneficial fatty acid composition to consumers. Similar conclusion could be drawn also for the effect of sex, where better fatty acid composition of male lambs could be probably partly attributed to lower intramuscular fat content.

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