VEAL QUALITY AND FATTY ACIDS CONTENT IN HOLSTEIN CALVES AT DIFFERENT DIETS

Klára Vavrišínová[1], Štefan Prívara[1], Juraj Čuboň[1], Peter Haščík[1], Vladimír Foltys[2]
[1]*Slovak University of Agriculture Nitra, Tr. A. Hlinku 2, 94976 Nitra, Slovak Republic*
[2]*Animal Production Research Centre Nitra, Hlohovecká 2, 951 41 Lužianky, Slovak Republic*

Corresponding author: Klára Vavrišínová
E-mail: klara.vavrisinova@uniag.sk

Abstract. Effect of feed on meat and adipose tissue fatty acid composition has become an object of concern. The aim of this work was to monitor the meat yield of Holstein calves and fatty acid composition of meat. The experiment included 12 Holstein young bulls divided into two groups. After weaning, the animals in group I were fed with grain feed and hay (lucerne-grass) and in group II animals were fed hay, grain feed and maize silage. The animals were fed for 150 days. Higher individual differences in fattening indicators were revealed mainly in the second group. Significant differences were found in the percentage of carcass yield, round meat, tenderloin, pH_{24}, meat colour (L value) and weaning weight. Group II showed significantly higher proportion of saturated fatty acids C16:0, C18:0 ($P \leq 0.05$), C20:0 ($P \leq 0{,}001$), monounsaturated fatty acids C16:1 ($P \leq 0.05$), C18:1 ($P \leq 0.01$) and *n*-3 polyunsaturated fatty acids C20:5 *n*-3 ($P \leq 0.001$) and C22:6 *n*-3 ($P \leq 0.05$). The diet in group I produced significantly higher amounts of C18:2 *n*-6 ($P \leq 0.001$) and C18:3 *n*-3 ($P \leq 0.01$) than group II. Addition of maize silage leads to higher production of *n*-3 PUFAs with long- chain (EPA, DHA) and lowering *n*-6/*n*-3 ratio.

Keywords: veal, quality, Holstein, fattening, carcass value, fatty acids.

SKIRTINGŲ DIETŲ ĮTAKA HOLŠTEINO VERŠELIŲ MĖSOS KOKYBEI IR SOČIŲJŲ RŪGŠČIŲ SUDĖČIAI

Klára Vavrišínová[1], Štefan Prívara[1], Juraj Čuboň[1], Peter Haščík[1], Vladimír Foltys[2]
[1]*Nitros žemės ūkio universitetas, Tr. A. Hlinku 2, 94976 Nitra, Slovakijos Respublika*
[2]*Slovakijos gyvulininkystės institutas, Hlohovecká 2, 951 41 Lužianky, Slovakijos Respublika*

Santrauka. Jau kurį laiką mokslininkai domisi šėrimo įtaka mėsos riebalų rūgščių ir riebalinių audinių sudėčiai. Šio darbo tikslas – įvertinti šėrimo įtaką Holšteino veršelių skerdenų išeigai ir mėsos riebalų rūgščių sudėčiai. Bandymui panaudota 12 Holšteino veislės veršelių, suskirstytų į dvi grupes. Atjunkyti I grupės veršeliai buvo šeriami grūdais ir šienu (liucerna). II grupės veršeliai buvo šeriami grūdais, šienu ir kukurūzų silosu. Bandymas truko 150 dienų. Didesni individualūs svorio augimo (arba penėjimosi rodiklių – prieaugio, svorio) skirtumai pastebėti tarp II grupės veršelių. Nustatyti ir kiti reikšmingi skirtumai: skerdenos išeigos (procentais), šlaunų mėsos, nugarinės, pH_{24}, mėsos spalvos (L), o atjunkymo metu – svorio. II grupės veršelių mėsoje buvo daug daugiau sočiųjų riebalų rūgščių C16:0, C18:0 ($p \leq 0{,}05$), C20:0 ($p \leq 0{,}001$); monosočiųjų riebalų rūgščių C16:1 ($p \leq 0{,}05$), C18:1 ($p \leq 0{,}01$) ir *n*-3; polisočiųjų riebalų rūgščių C 20:5 *n*-3 ($p \leq 0{,}001$) ir C 22:6 *n*-3 ($p \leq 0{,}05$). Tuo tarpu I grupės veršelių (šėrimas turėjo įtakos žymiai didesniam C18:2 *n*-6 kiekiui mėsoje nei II grupės) mėsoje buvo daug daugiau C18:2 *n*-6 ($p \leq 0{,}001$) ir C18:3 *n*-3 ($p \leq 0{,}01$) nei II grupės. Kukurūzų silosas priedas padidino *n*-3 PNRR (polinesočiųjų riebalų rūgščių), tarp jų – ilgosios grandinės eikozapentaeno ir dokozaheksaeno rūgščių (EPR, DHR) kiekį mėsoje ir sumažino polinesočiųjų *n*-6/*n*-3 santykį.

Raktažodžiai: veršiena, kokybė, Holšteino veislės veršeliai, svorio augimas, mėsingumas, riebalų rūgštys.

Introduction. Holstein calves (n=12) have a very good carcass composition and meat protein and fat content are favourable (Skřivanová et al., 1999). Falta and Chládek (2008) for meat production. Calves were housed and fattened under the same conditions on a starter mixture and adding 1 l milk in the morning and 1 l in the evening. Carcass weight was on average 102.5 kg at the age from 3.8 to 5 months. Statistically significant ($P<0.01$) correlation between age and live weight before slaughter ($r = 0.69$), and carcass right half weight ($r = 0.97$) was found. This fact indicates that the factors affecting the carcass weight and thus the proportion of individual cuts are directly influenced by the farmer. Skřivanová et al. (1999) introduced the following performance characteristics of dairy calves: live weight at the age of 111.4 days was 141.4 kg, carcass yield 58.6 %, the right half weight 41.5 kg, individual cuts weight: shoulder, boneless 3.3 kg, boneless rump 10.0 kg. Protein content of *musculus longissimus dorsi* was 206.3, fat $g.kg^{-1}$. Technological properties of the sample were as follows: colour of meat in remission 31.8 %, drip loss 2.6 % after 24 hours and 5.4 % after 48 hours, pH_{24} 5.48.

Exploration of the feasibility of producing grain-fed veal was the objective of the study by Johnson et al. (1992). Fifteen Holstein bull calves and two Holstein beef cross females were fed only milk or were weaned by 28 d

and fed concentrate. Mean slaughter age was 127 days for both groups. Average birth weight, final BW and average daily gains were 98, 98, and 97 % as much for grain-fed calves and for milk-fed. Growth rate (day 28 to 127) was 1.1 kg/day for grain feeding compared with 1.0 kg/day (less than expected) for milk feeding. Milk feeding resulted in lower lean and overall maturity scores, lighter colour, more flank fat streaking; greater fat thickness, more kidney, pelvic, and heart fat, lower Warner-Bratzler shear values of loin chops, and higher percentage graded as veal. Composition of *longissimus* muscle, cooking characteristics, attributes and sensory panel did not differ. Lean maturity and colour were not related to shear values or sensory panel evaluations. Total pigment content was positively correlated with flavour intensity (Lagoda et al., 2002).

The meat colour, being one of the most important quality criteria in the veal industry, is particularly susceptible to changes in dietary Fe concentrations, minimal levels of which must be maintained to avoid anaemia. The colour of veal muscle tissue is one of the criteria by which the consumer evaluates its quality.

Šubrt et al. (2007) found the following values of colour for different categories of cattle meat: bulls: L * (%) 34.40 to 37.20, a * (%) 10.29 to 12.67, b * (%) 7.83 to 10.36; heifers: L * (%) 36.11 to 38.69, a * (%) 10.95 to 13.91, b * (%) 9.00 to 11.59; steers: L * (%) 35.38 to 37.15, a * (%) 10.91 to 12.88, b * (%) 8.23 to 10.00 depending up diet.

Beef including veal is an excellent source of nutrients such as proteins, B_6 and B_{12} vitamins, Fe^{2+} and Zn^{2+}. On the other hand, animal fat is considered unhealthy and there are attempts to minimize its content in animal products (Wood, et al. 2008).

A number of studies have examined the effect of different combinations of concentrate and/or forage or pasture diet on animal performance, carcass quality and meat properties of cattle (French et al. 2000; Cooker et al. 2004; O'Sullivan et al. 2004; Marino et al. 2006; Daly et al. 2007; Dannenberger et al. 2007; Huuskonen et al. 2007; Serrano et al. 2007; del Campo et al. 2008; Warren et al. 2008; Sami et al. 2010). The effect of feed on meat and adipose tissue fatty acid composition has been analysed in partocular (Wood et al. 1999; Scollan et al. 2001; Nuernberg et al. 2005; Valsta et al. 2005; Gill et al. 2008; Fincham et al. 2009; Daley et al. 2010; de Menezes et al. 2010; Dierking et al. 2010).

Two important microbial transformations, which take place in the rumen, have been identified: lipolysis and biohydrogenation. Lipolysis causes the release of FFA from esterified plant lipids followed by biohydrogenation, which reduces the number of double bonds (Jenkins 1993; Fievez et al. 2007).

Lean beef has an intramuscular fat content of around 5% or less with approximately 47 % of total fatty acids as saturated fatty acids (SFA), 42 % monounsaturated fatty acids (MUFA) and 4 % PUFA respectively. The PUFA:SFA ratio for beef is typically low at around 0.1 (Scollan et al. 2005), except for double muscled animals which are very lean (<1 % intramuscular fat) with the PUFA:SFA ratio typically being 0.5-0.7 (Raes 2004).

Conversion dietary PUFA to more saturated end-products is the major reason why ruminant fats are highly saturated in nature. However, this biohydrogenation is also responsible for ruminant fats being the major source of conjugated linoleic acid a range of *cis* and *trans* conjugated isomers of octadecadienoic acid; some with important anticarcinogenic or antiatherogenic activities (Scollan, et al. 2005).

The extent of biohydrogenation of dietary PUFA is higher for 18:3n-3 than for 18:2n-6 (Wood et al. 2008). Feeding high-concentrate diets rich in 18:2n-6 decreases the proportion of CLA and n-3 fatty acids in intramuscular fat (IMF) in comparison with conserved forages or pasture finishing (Raes 2004; Faucitano et al. 2008). Grass-based diets enhance CLA, *trans* vaccenic acid (TVA) and n-3 PUFA content (Daley, et al. 2010) but more effectively in phospholipids of muscle fibres than in neutral lipids of intramuscular fat (Wood, et al. 2008).

The aim of this work was to monitor the meat yield and meat fatty acid composition of two groups of Holstein calves fed different diets after weaning.

Materials and Methods. The experiment included 12 Holstein young bulls. Animals were divided into two groups according to the method of feeding. In the first stage of the experiment (to the weaning = 60 days), all animals were fed with the dairy feed mixture and starter feed mixture. During this period calves were housed individually in outdoor barns. Then (from 60 days) calves were housed in barns in 2 groups with differential feeding: animals in group I were fed with feed mixture and hay (lucerne-grass) and in group II animals were fed with hay, feed mixture and maize silage.

Table 1. **The scheme of calves feeding**

Period	Group I	Group II
From birth to 60 days	Dairy feed mixture + Feed mixture-starter	Dairy feed mixture + Feed mixture-starter
From 60 to 150 days	Feed mixture + Hay	Feed mixture + Hay + Maize silage

The used standard feed mixtures were produced and balanced for monitored category. The animals were chosen randomly.

Body weight at birth (kg), body weight at weaning (kg) and the average daily weight gain (g) during the experiment were observed. The total length of fattening (from birth to slaughter) was 150 days.

Carcasses were chilled for 24 hours after slaughter and then carcass dissection was carried out. Parameters of carcass dissection were observed from the right half. The

sample of meat taken from *musculus longissimus dorsi* (MLD) was analysed for qualitative parameters. Percentage of free water was investigated as drip loss and pH values (an hour and 24 hours after slaughter) were investigated using Titan pH meter. The colour of the meat was measured at the fresh section with spectrophotometric device Conica Minolta CM 2600 D. MLD area was measured planimetricaly at the level of 9th thoracic vertebra.

Fatty acid composition of MLD was determined according to Juárez et al. (2008) from fat sample obtained from MLD by Folch extraction (Folch et al. 1957). Separation of the fatty acids methyl esters (FAMEs) was carried out by means of gas chromatograph (GC, Agilent 6890N) equipped with a flame ionization detector (FID). A fused silica capillary column RTX - 225 (30 m · 0.53 mm i.d. 1.0 μm film thickness) coated with 50 % cyanopropyl-phenyl-dimethylpolysiloxane was used. The injector and detector temperatures were set at 250 °C. The oven temperature was kept at 160 °C for 1 min, then programmed from 160 °C to 190 °C at 3 °C /min, from 190 °C to 250 °C at 2 °C /min and, finally, kept at 250 °C for 15 min. Helium was used as carrier gas at a flow rate of 1.0 ml/min (pressure, 120 kPa); the split ratio was 1:20. The peak identification was determined by comparing the peak retention times with those of the FAMEs standard mixture.

Statistical analysis of the data was performed by the SAS 8.2 software. Significance of differences was evaluated by t-test.

Results and discussion. Table 2 shows the statistical indicators of fattening. Prior weaning (60 days) both groups were fed equally. After the weaning, group I was fed with feed mixture and hay and group II with feed mixture, hay and maize silage. The animals were fattened for 150 days. Statistical difference was found in weaning weight. Higher individual differences in the indicators of fattening revealed mainly in group II. Higher growth intensity of diary calves compared to our results was reported by Skřivanová et al. (1999) in the study where the average slaughter weight of 141 kg was reached at the age of 114 days. Higher values also were determined by Johnson et al. (1992).

Table 3 shows that slightly higher carcass weight and carcass yield were reached by animals of group I. However higher proportions of intestinal and kidney fat were found in group II. Higher weight values were found in calves of group I. Significantly higher values (P≤0.05) of carcass yield were reached by animals of group I. Significant differences were found in the percentage of round meat and tenderloin (Table 4). Skřivanová et al. (1999) reported slightly higher values.

Values of pH and colour of the meat showed no qualitative deviations (Table 5). The lighter meat was found in group II. Drip loss values indicated drier meat. Statistical differences were found in the indicators: pH_{24} and colour (L value). The results showed a lighter colour than in other categories of cattle (Šubrt et al., 2007).

The proportional representations of fatty acids expressed as percentage of total fatty acids in longissimus muscle are summarized in Table 6. Group I C18:2 *n*-6 was the most abundant in fatty acids with representation 26.20 % of total fatty acids, followed by C18:1 (18.50 %) and C16:0 (16.88 %). Group II showed the highest representation of C18:1 (21.89 %), followed by C16:0 (18.46 %) and C18:2 *n*-6 (18.29 %). Group II showed significantly higher proportion of saturated fatty acids C16:0, C18:0 (P≤0.05), C20:0 (P≤0,001), monounsaturated fatty acids C16:1 (P≤0.05), C18:1 (P≤0.01) and *n*-3 polyunsaturated fatty acids C20:5 *n*-3 (P≤0.001) and C22:6 *n*-3 (P≤0.05). The diet in group I produced significantly higher amounts of C18:2 *n*-6 (P≤0.001) and C18:3 *n*-3 (P≤0.01) than group II.

Partial replacing of feed mixture with silage in group II leads to increased proportion of saturated and monounsaturated fatty acids and decrease of C18:2 *n*-6 which is similar to findings by Nuernberg, et al. (2005). This is due to high content of C18:2 *n*-6 in grain (concentrate) feed used in fattening of cattle while forage diet, rich in C18:3 *n*-3, is more prone to biohydrogenation in rumen because of prolonged rumen transit time (Wood, et al. 2008). This could explain higher proportion of saturated and monounsaturated fatty acids in group I (based on grain feed). Extend of biohydrogenation of C18:3 *n*-3 in rumen is often higher than 90 %. Furthermore incorporation of C18:3 *n*-3 into lipids is less effective than C18:2 *n*-6 (Raes 2004) and after absorption is partly desaturated and elongated to long chain PUFAs (Wood, et al. 2008). This could be an explanation of even lower representation of C18:3 *n*-3 in group II compared to group I. Grass-based feed (pasture or grass silage) seems to be more effective in increasing *n*-3 PUFAs content (Nuernberg, et al. 2005; Warren, et al. 2008).

Table 2. **Fattening parameters**

	Group I		Group II		*Significance*
	Mean	S.E.M	Mean	S.E.M	
Birth weight (kg)	37.28	1.15	34.58	1.29	ns
Weaning weight (kg)	82.95	2.55	89.75	2.08	*
Slaughter weight (kg)	145.60	3.60	149.08	7.60	ns
Average daily gain (from birth to slaughter)(kg)	0.72	0.02	0.75	0.04	ns

Group I: hay + feed mixture; Group II: hay + feed mixture + maize silage
* P≤0.05; ** P≤0.01; *** P≤0.001; ns not significant

Table 3. **Carcass parameters**

	Group I		Group II		*Significance*
	Mean	S.E.M	Mean	S.E.M	
Average carcass weight (kg)	75.70	2.75	67.75	3.59	ns
Carcass yield (%)	51.09	1.34	45.47	0.80	*
Rumen fat (%)	0.67	0.15	0.44	0.06	ns
Intestinal fat (%)	0.15	0.02	0.19	0.04	ns
Kidney fat (%)	0.80	0.16	0.95	0.06	ns

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$; ns not significant
% values were calculated from slaughter weight

Table 4. **Proportion of selected carcass parts**

	Group I		Group II		*Significance*
	Mean	S.E.M	Mean	S.E.M	
Round meat (boneless) (%)	21.61	0.65	19.59	0.30	*
Shoulder (boneless) (%)	7.90	0.34	7.24	0.17	ns
Tenderloin (%)	1.86	0.03	1.61	0.06	*
MLD area (cm^2)	29.88	4.84	30.68	2.35	ns

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$; ns not significant
% values were calculated from right half weight

Table 5. **Qualitative parameters**

	Group I		Group II		*Significance*
	Mean	S.E.M	Mean	S.E.M	
pH_1	6.16	0.04	6.17	0.06	ns
pH_{24}	5.84	0.02	6.12	0.05	***
Drip water loss (%)	0.67	0.09	0.66	0.11	ns
Meat colour (MLD) L*(D65)	44.12	0.96	47.53	1.53	ns
Meat colour (MLD) a*(D65)	5.99	0.18	4.73	0.65	ns
Meat colour (MLD) b*(D65)	10.23	0.61	11.16	0.42	ns

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$; ns not significant

Table 6. **Fatty acid composition** (% of total fatty acids) **of lipids in *musculus longissimus dorsi* of calves fed with and without silage**

	Group I		Group II		*Significance*
	Mean	S.E.M	Mean	S.E.M	
C14:0	0.27	0.04	0.40	0.08	ns
C16:0	16.88	0.20	18.46	0.48	*
C16:1	0.63	0.09	0.90	0.05	*
C18:0	12.79	0.36	14.26	0.46	*
C18:1	18.50	0.68	21.89	0.52	**
C18:2 *n*-6	26.20	1.11	18.29	0.61	***
C18:3 *n*-3	0.75	0.05	0.53	0.03	**
C20:0	0.07	0.01	0.14	0.01	***
C20:4 *n*-6	10.74	0.39	11.78	0.22	ns
C20:5 *n*-3	0.36	0.03	0.76	0.07	***
C22:6 *n*-3	1.53	0.07	1.81	0.06	*
Other	11.30	0.88	10.77	0.77	ns
PUFA:SFA	1.32	0.07	0.98	0.03	**
n-6/ *n*-3	14.10	0.43	9.74	0.47	***

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$; ns not significant; other: C16 – C22 isomers not included in the list

Due to higher saturated fatty acids proportion in group II, PUFA:SFA ratio is significantly ($P \leq 0.01$) lower in group II (0.98) than in group 1 (1.32). Ratio *n*-6/ *n*-3 polyunsaturated fatty acids 9.74 in group II was significantly lower ($P \leq 0.001$) than ratio 14.10 in group I.

The lower PUFA:SFA ratio 0.98 in group II meets nutritional recommendations to maintain this ratio higher than 0.4 (Wood, et al. 2008), but the most abundant PUFA is C18:2 *n*-6. The lower *n*-6/*n*-3 ratio 9.74 in group II still remains higher than the recommended value which is lower than 4 (Simopoulos 2008). Warren, et al. (2008) reached values lower than 2 when replaced concentrate diet with grass silage in the experiment with even older Aberdeen Angus and Hereford steers.

Conclusions

During the experiment, the meat yield and meat fatty acid composition of Holstein calves (n=12) were observed. The animals were divided into two groups according to the method of feeding. Calves of group II revealed higher fattening parameters. Conversely better parameters of carcass value were found in group I. Animals in group II showed better meat colour characteristics. Higher individual differences among animals were found in group II. The results of the study show that addition of maize silage leads to higher production of *n*-3 PUFAs with long chain (EPA, DHA) and lowering *n*-6/*n*-3 ratio, but in our case does not reach nutritionally recommended value bellow 4 while PUFA/SFA ratio increased mainly due to higher incorporation of C18:2 *n*-6.

Acknowledgements

Financial support was provided by Ministry of Education Slovak Republic (Grant VEGA 1/0575/10) and by project Excellence Centre for Agrobiodiversity Conservation and Benefit – ECACB Plus (Project ITMS Code: 26220120032) implemented under the Operational Programme Research and Development financed by European Regional Development Fund (ERDF).

References

1. Andrae, J.G., Duckett, S.K., Hunt, C.W., Pritchard, G.T., Owens, F.N. Effects of feeding high-oil corn to beef steers on carcass characteristics and meat quality. Journal of Animal Science. 2001. V. 79. P. 582–588.

2. Cooker, D.W.I., Monahan, R., Brophy, P.O., Boland, M.P. Comparison of concentrates or concentrates plus forages in a total mixed ration or discrete ingredient format: effects on beef production parameters and on beef composition, colour, texture and fatty acid profile. Irish Journal of Agricultural and Food Research. 2004. V. 43. P. 201–216.

3. Daley, C.A., Abbott, A., Doyle, P.S., Nader, G.A., Larson, S. A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef. Nutrition journal. 2010. V. 9. P. 10.

4. Daly, C., Moloney, A., Monahan, F. Lipid and colour stability of beef from grazing heifers supplemented with sunflower oil alone or with fish oil. Meat science. 2007. V. 77. P. 634–642.

5. Dannenberger, D., Nuernberg, G., Scollan, N., Ender, K., Nuernberg, K. Diet alters the fatty acid composition of individual phospholipid classes in beef muscle. Journal of Agricultural and Food Chemistry. 2007. V. 55. P. 452–460.

6. De Menezes, L.F.G., Kozloski, G.V., Restle, J., Brondani, I.L., Pazdiora, R.D., Cattelam, J. Profile of ingested fatty acids and in the duodenal digest of steers fed different diets. Revista Brasileira De Zootecnia-Brazilian Journal of Animal Science. 2010. V. 39. P. 2502–2511.

7. Del Campo, M., Brito, G., De Lima, J.M.S., Martins, D.V., Sanudo, C., Julian, R.S., Hernandez, P., Montossi, F. Effects of feeding strategies including different proportion of pasture and concentrate, on carcass and meat quality traits in Uruguayan steers. Meat science. 2008. V. 80. P. 753–760.

8. Dierking, R.M., Kallenbach, R.L., Grun, I.U. Effect of forage species on fatty acid content and performance of pasture-finished steers. Meat science. 2010. V. 85. P. 597–605.

9. Falta, D., Chládek, G. Vliv hmotnosti JUT na podíl jednotlivých výsekových částí telat-býčků holštýnského plemene skotu. In Filipčík, R. - Král, V. Šlechtění na masnou užitkovost a aktuální otázky produkce jatečných zvířaV. 1. vyd. Rapotín: MZLU v Brně, Asociace chovatelů masných plemen Rapotín, Agrovýzkum Rapotín s.r.o., 2008. ISBN 978-80-903143-8-2. P. 111–114.

10. Faucitano, L., Chouinard, P.Y., Fortin, J., Mandell, I.B., Lafreniere, C., Girard, C.L., Berthiaume, R. Comparison of alternative beef production systems based on forage finishing or grain-forage diets with or without growth promotants: 2. Meat quality, fatty acid composition, and overall palatability. Journal of animal science. 2008. V. 86. P. 1678–1689.

11. Fievez, V., Vlaeminck, B., Jenkins, V., Enjalbert, F., Doreau, M. Assessing rumen biohydrogenation and its manipulation in vivo, in vitro and in situ. European Journal of Lipid Science and Technology. 2007. V. 109. P. 740–756.

12. Fincham, J.R., Fontenot, J.P., Swecker, W.S., Herbein, J.H., Neel, J.P.S., Scaglia, G., Clapham, W.M., Notter, D.R. Fatty acid metabolism and deposition in subcutaneous adipose tissue of pasture- and feedlot-finished cattle. Journal of animal science. 2009. V. 87. P. 3259–3277.

13. Folch, J., Lees, M., Stanley, G.H.S. A simple method for the isolation and purification of total lipides from animal tissues. Journal of Biological Chemistry. 1957. V. 226. P. 497–509.

14. French, P., Stanton, C., Lawless, F., O'riordan, E.G., Monahan, F.J., Caffrey, P.J., Moloney, A.P. Fatty acid composition, including conjugated linoleic acid, of intramuscular fat from steers offered grazed grass, grass silage, or concentrate-based diets. Journal

of animal science. 2000. V. 78. P. 2849–2855.

15. Gill, R.K., Vanoverbeke, D.L., Depenbusch, B., Drouillard, J.S., Dicostanzo, A. Impact of beef cattle diets containing corn or sorghum distillers grains on beef color, fatty acid profiles, and sensory attributes. Journal of animal science. 2008. V. 86. P. 923–935.

16. Huuskonen, A., Khalili, H., Joki-Tokola, E. Effects of three different concentrate proportions and rapeseed meal supplement to grass silage on animal performance of dairy-breed bulls with TMR feeding. Livestock Science. 2007. V. 110. P. 154–165.

17. Jenkins, V.C. Lipid-Metabolism in the Rumen. Journal of dairy science. 1993. V. 76. P. 3851–3863.

18. Johnson, D.D., Van Horn, H.H., West, R.L., Harris, B. Effect of Calf Management on Carcass Characteristics and Palatability Traits of Veal Calves.Journal of Dairy Science. V. 75, 1992. P. 2799-2804.

20. Juárez, M., Polvillo, O., Contò, M., Ficco, A., Ballico, S., Failla, S. Comparison of four extraction/methylation analytical methods to measure fatty acid composition by gas chromatography in meat. Journal of Chromatography A. 2008. V. 1190. P. 327–332.

21. Marino, R., Albenzio, M., Girolami, A., Muscio, A., Sevi, A., Braghieri, A. Effect of forage to concentrate ratio on growth performance, and on carcass and meat quality of Podolian young bulls. Meat science. 2006. V. 72. P. 415–424.

22. Lagoda HL, Wilson LL, Henning WR, Flowers SL, Mills EW. Subjective and objective evaluation of veal lean color. Journal of Animal Science. 2002 Jul; 80(7): 1911-6.

23. Ngapo, V.M., Gariépy, C. Factors affecting the meat quality of veal. Journal of the Science of Food and Agriculture. 86, 2006. P. 1412–1431.

24. Nuernberg, K., Dannenberger, D., Nuernberg, G., Ender, K., Voigt, J., Scollan, N.D., Wood, J.D., Nute, G.R., Richardson, R.I. Effect of a grass-based and a concentrate feeding system on meat quality characteristics and fatty acid composition of longissimus muscle in different cattle breeds. Livestock Production Science. 2005. V. 94. P. 137–147.

25. O'Sullivan, A., O'Sullivan, K., Galvin, K., Moloney, A.P., Troy, D.J., Kerry, J.P. Influence of concentrate composition and forage type on retail packaged beef quality. Journal of animal science. 2004. V. 82. P. 2384–2391.

26. Raes, K. Effect of dietary fatty acids on incorporation of long chain polyunsaturated fatty acids and conjugated linoleic acid in lamb, beef and pork meat: a review. Animal Feed Science and Technology. 2004. V. 113. P. 199–221.

27. Sami, A.S., Schuster, M., Schwarz, F.J. Performance, carcass characteristics and chemical composition of beef affected by lupine seed, rapeseed meal and soybean meal. Journal of animal physiology and animal nutrition. 2010. V. 94. P. 465–473.

28. Scollan, N.D., Choi, N.J., Kurt, E., Fisher, A.V., Enser, M., Wood, J.D. Manipulating the fatty acid composition of muscle and adipose tissue in beef cattle. British Journal of Nutrition. 2001. V. 85. P. 115–124.

29. Scollan, N.D., Richardson, I., De Smet, S., Moloney, A.P., Doreau, M., Bauchart, D., Nuernberg, K. Enhancing the content of beneficial fatty acids in beef and consequences for meat quality. Indicators of Milk and Beef Quality. 2005. P. 151–162

30. Scollan, N.D., Richardson, I., Moloney, A.P. Effect of beef systems on meat composition and quality. Proceedings of the 8th Langford Food Industry Conference, University of Bristol, 2005, P. 1–5.

31. Serrano, E., Pradel, P., Jailler, R., Dubroeucq, H., Bauchart, D., Hocquette, J.F., Listrat, A., Agabriel, J., Micol, D. Young Salers suckled bull production: effect of diet on performance, carcass and muscle characteristics and meat quality. Animal. 2007. V. 1. P. 1068–1079.

32. Simopoulos, A.P. The omega-6/omega-3 fatty acid ratio, genetic variation, and cardiovascular disease. Asia Pacific Journal of Clinical Nutrition. 2008. V. 17. P. 131–134.

33. Skřivanová, V., Laštovková, J., Klein, P., Šimák, P. Systémy mléčného výkrmu telaV. Metodiky pro zemědělskou praxi, UZPI MZ ČR Praha, V. 10, 1999. ISBN80-7271-035-4. 39 p.

34. Šubrt, J., Bjelka, M., Filipčík, R., Homola, M., Simeonová, J. Kvalita hovězího masa v různých systémech výkrmu. Výkrm skotu a nové metody hodnocení konzervovaných krmív. Sb. příspěvků z mezinár. semináře Pohořelice., 2007. ISBN 978-80-903142-9-0. P.48–60.

35. Valsta, L.M., Tapanainen, H., Mannisto, S. Meat fats in nutrition. Meat science. 2005. V. 70. P. 525–530.

36. Warren, H.E., Scollan, N.D., Enser, M., Hughes, S.I., Richardson, R.I., Wood, J.D. Effects of breed and a concentrate or grass silage diet on beef quality in cattle of 3 ages. I: Animal performance, carcass quality and muscle fatty acid composition. Meat science. 2008. V. 78. P. 256–269.

37. Wood, J.D., Enser, M., Fisher, A.V., Nute, G.R., Richardson, R.I., Sheard, P.R. Manipulating meat quality and composition. Proceedings of the Nutrition Society. 1999. V. 58. P. 363–370.

38. Wood, J.D., Enser, M., Fisher, A.V., Nute, G.R., Sheard, P.R., Richardson, R.I., Hughes, S.I.,

Whittington, F.M. Fat deposition, fatty acid composition and meat quality: A review. Meat science. 2008. V. 78. P. 343–358.

Received 3 October 2011
Accepted 11 January 2013