IMPACT OF GENOTYPE ON CATTLE GROWTH, BEEF CHEMICAL COMPOSITION AND CHOLESTEROL LEVEL

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Summary. This paper presents data on the impact of genotype on the growth rate and live weight of cattle under 500 days of the age; on the beef chemical composition, intramuscular fat and cholesterol level. The breeds tested included Lithuanian Black and White, Lithuanian Red, Charolais, Simental, Aubrac and the crossbreds of these purebred cattle with the Lithuanian dairy cows.

Compared with Lithuanian Black and White cattle the highest weight in the purebred group had Charolais (+168.5 kg, P<0.05) and Simental (+110.5 kg, P<0.05); in the crossbred group, Lithuanian Red x Charolais (+45.5 kg, P<0.05) and Lithuanian Black and White x Simental (+34.8 kg, P<0.05) had the highest weight. Comparable tendency was observed in daily gain: for Charolais it was 168 g (P<0.01), for Simental 118 g (P<0.05), for Lithuanian Red x Charolais 87 g (P<0.01), and for Lithuanian Black and White x Simental − 82 g (P<0.05), respectively.

Dry matter content in the beef varied from 24.7 % in Aubrac to 26.1 % in Lithuanian Red x Simental crossbred meat. Significant differences were observed in protein content, but there was no correlation between the dry matter and protein content in the beef from both groups.

The intramuscular fat content in *M. longissimus dorsi* from different genotypes of cattle varied from 1.10 to 2.72 %. The highest levels of intramuscular fat were found in Lithuanian Black and White and Lithuanian Red purebred bull meat, the lowest - in Aubrac and in Charolais purebred bull meat (P<0.001).

The cholesterol content in the beef ranged from 48.5 to 57.5 mg/ 100 g. The ranges were lower on 1.1-15.5 % for purebreds and on 6.8-14.4 % for crossbreds compared with Lithuanian Black and White purebreds. The highest cholesterol level was determined in Lithuanian Black and White and Lithuanian Red purebreds. However, significant differences in cholesterol level were observed in beef from Lithuanian Black and White x Aubrac and Lithuanian Red x Aubrac: 11.7 and 14.4 % (P<0.05), respectively. Low correlations between the cholesterol content and intramuscular fat content were determined (r<0.32).

Keywords: daily gain, protein, intramuscular fat, cholesterol, bull, muscle.

GENOTIPO ĮTAKA GALVIJŲ AUGIMO SPARTAI, JAUTIENOS CHEMINEI SUDĖČIAI IR CHOLESTEROLIO KIEKIUI

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Santrauka. Straipsnyje pateikti duomenys apie genotipo įtaką galvijų augimo spartai, svoriui, mėsos cheminei sudėčiai, tarpraumeninių riebalų ir cholesterolio kiekiui. Tirti 500 dienų Lietuvos juodmargiai, Lietuvos žalieji, šarolė, simentaliai, aubrakų ir šių grynaveislių galvijų mišrūnai su lietuviškosiomis pieninėmis karvėmis.

Palyginti su Lietuvos juodmargiais daugiausia svėrė šarolė (+168,5 kg; p<0,05) ir simentaliai (+110,5 kg; p<0,05), Lietuvos žalųjų x šarolė (+45,5 kg; p<0,05) ir Lietuvos juodmargių x simentalių (+34,8 kg; p<0,05) mišrūnai. Ta pati tendencija pastebėta ir priesvorio rodiklio – šarolė priaugo 168 g (p<0,01), simentaliai – 118 g (p<0,05), Lietuvos žalųjų x šarolė mišrūnai – 87 g (p<0,01) ir Lietuvos juodmargių x simentalių mišrūnai – 82 g (p<0,05).

Sausųjų medžiagų kiekis kito nuo 24,7 proc. aubrakų mėsoje iki 26,1 proc. Lietuvos žalųjų x simentalių mišrūnų mėsoje. Reikšminiai skirtumai pastebėti tarp baltymų kiekio skirtingoje jautienoje, tačiau nei grynaveislių, nei mišrūnų grupėje nenustatyta koreliacija tarp sausųjų medžiagų ir baltymų kiekio.

Skirtingo genotipo galvijų *M. longissimus dorsi* raumenyse tarpskaidulinių riebalų kiekis kito nuo 1,10 iki 2,72 proc. Daugiausia jų – Lietuvos juodmargių ir Lietuvos žalųjų mėsoje, mažiausiai – aubrakų ir šarolė galvijų mėsoje (p<0,001).

Cholesterolio nustatyta 48,5–57,5 mg/100 g. Palyginti su Lietuvos juodmargiais grynaveislių galvijų cholesterolio buvo 1,1–15,5 proc., mišrūnų – 6,8–14,4 proc. mažiau. Didžiausios šio rodiklio vertės gautos tiriant Lietuvos juodmargių ir Lietuvos žalųjų mėsą. Vis dėlto šių veislių mišrūnų mėsoje (Lietuvos juodmargės ir Lietuvos žalosios su aubrakais) buvo reikšmingai sumažėjęs cholesterolio kiekis – atitinkamai 11,7 ir 14,4 proc. (p<0,05). Koreliacija tarp cholesterolio ir tarpraumeninių riebalų kiekio buvo labai silpna (r<0,32).

Raktažodžiai: priesvoris, baltymai, tarpskaiduliniai riebalai, cholesterolis, buliai, raumuo.

Introduction. The annual consumption of beef per capita reached a peak of 36.7 kg in 1976, it steadily declined until a low 26.2 kg was reached in 2001, and has remained fairly constant since then. Conversely, during the same period, the consumption of broilers per capita has steadily increased from 15.8 kg in the beginning of the period to 28.6 kg in the end (Variyam et al., 2000; Peterson et al., 2001; Piironen et al., 2002). Economists have been debating whether this change is related to consumer health concerns about the fat and cholesterol content of the various meat products (Capps & Schmitz, 1991; McGuirk, Driscoll, Alwang, & Huang, 1995). A balanced diet should contain safe red meat products (Sofos, 2008; Vandendriessche, 2008), as lean meat provides a variety of nutrients required for a healthy lifestyle (Schönfeldt & Gibson, 2008; Wood et al., 2008). Despite the positive contribution of adipose tissue to the appearance, the texture, flavor, firmness, caloric value, and shelf-life of red meat products (Dransfield, 2008; Ngapo & Gariepy, 2008; Web and O'Neill, 2008; Wood et al., 2008), exceeded adipose tissue (Wood et al., 2008), and meat products containing saturated fatty acids (Wood et al., 2008) are considered unhealthy (Schönfeldt & Gibson, 2008; Web & O'Neill, 2008; Hausman et al., 2009).

Meat and meat products are important sources of proteins, vitamins, and minerals. However, they also contain elements that in certain circumstances and unsuitable proportion have a negative effect on human health. Today's consumers are more interested in knowing what they are really eating. Consumers of meat are concerned that a diet containing red meat is rich in total fat, saturated fat and cholesterol. Farmers try to offer 'healthier' meat for human consumption through changing the animal feed consumption and genetic improvement. The intramuscular fat plays an important role in meat quality. It is known that not only the amount but also structure of the fat plays a major role in maintaining human health (Nuernberg et al., 2005).

The amount of fat in meat can vary widely depending on various factors: the species of animal, the particular cut of meat, the degree of separation of fat from the meat in the various handling phases, cooking technique, etc (Jimenez-Colmenero et al., 2001). Meat, especially red, is commonly identified as a major source of dietary cholesterol. However, the amount of cholesterol in lean meat, were the visible fat has been removed is low when compared to amount which is produced each day in the human body (Piironen et al., 2002). Cholesterol is a substance vital to life. It is found in all cells of the body and it plays a basic role both as a precursor molecule of hormones and other major molecules, and as a structural element of membranes.

The need to evaluate cholesterol content in foods has become increasingly important for few reasons. The major is the health concern about the atherogenic role of excess plasma cholesterol and the influence of dietary intake on the level of plasma lipids. It has recently become apparent that the development of atherosclerosis and coronary heart disease might be largely due to decreased levels of high-density lipoproteins (HDL). This appears to be due to the function of HDL in transporting cholesterol out of the arterial wall while inhibiting the uptake of low-density lipoprotein by vascular smooth muscle (Hurst et al., 1984). In order to get some meat on the qualitative characteristics (low intramuscular fat and cholesterol content, good marbling, etc.) executed an intensive selection (Jukna, C. et al., 2006).

Molecular methods have yielded a variety of linkages between specific genes and numerous meat quality characteristics such as fatness (Dekkers, 2004; Michal et al., 2006; Sasaki et al., 2006; Hausman et al., 2009; Taniguchi et al., 2008).

The aim of this study was to evaluate the impact of genotype on the cattle growth rate and live body weight under 500 days of the age, beef chemical composition and cholesterol level.

Material and methods. The studied animals, pure and crossbred bulls, were grown at the control fattening station in the same keeping conditions and slaughted at 500 days age. The live body weight was determined by weighing animal before slaughter.

In order to evaluate the breed impact on dry matter, protein, intramuscular fat and cholesterol content in beef several animals - Lithuanian Black and White (LBW, n=25), Lithuanian Red (LR, n=23), Simental (n=20), Charolais (n=17) and Aubrac (n=21) purebred and Lithuanian Black and White x Simental (LBWxSimental, n=17), Lithuanian Red x Simental (LRxSimental, n=18), Lithuanian Black and White x Aubrac (LBWxAubrac, n=16), Lithuanian Red x Aubrac (LRxAubrac, n=17) and Lithuanian Red x Charolais (LRxCharolais, n=19) crossbred bulls were slaughtered.

Samples have been taken from *M. longissimus dorsi* at the last rib. Intramuscular fat content analysis was performed by Soxhlet method (AOAC International, 2007), protein content and dry matter were determined according LST ISO 937:2000 and LST ISO 1442:2000, respectively. For determination of cholesterol amount chromatographic methodology approved in the EU was used.

Chromatographic analysis

HPLC or analytical grade chemicals and solvents were used (Merck, Germany).

The method by *Folch et al.* (1957) was used for lipid extraction from meat samples. After extraction the solvent was subsequently evaporated to dryness under a nitrogen stream at 60°C, and the residues were dissolved in 1 ml of methanol. Reverse-phase HPLC was carried out with a C8 Nucleosil column (125 mm×4.6 mm, 4.6 µm spherical particles, Machery-Nagel). Was used Knauer chromatographic system K-2501 with autosampler model 3000 and UV detector, pumps Knauer K-501.

HPLC elution was accomplished under isocratic conditions with the mobile phase of acetonitrile/methanol:water (1/9:1, vol/vol) at 1 ml/min flow rate. The detection performed under ultraviolet-wavelength 205 nm.

Samples and standards were injected onto the column in duplicates. Results were calculated by comparing peak areas obtained by injection of samples and standards.

Statistical analysis. The R statistical package version

2.0.1. (Gentlemen, Ihaka, 1997) was used to estimate data.

Results and Discussion. Data on animal live weight and daily gain of different genotypes cattle are presented in Table 1. In comparison with Lithuanian Black and White cattle the highest live weight in purebreds group had Charolais (+168.5 kg, P<0.05) and Simental (+110.5 kg, P<0.05), between crossbred - Lithuanian Red x Charolais (+45.5 kg, P<0.05) and Lithuanian Black and White x Simental (+34.8 kg, P<0.05). The same tendency was observed in daily gain – for Charolais it was 168 g (P<0.01), Simental - 118 g (P<0.05), Lithuanian Red x Charolais – 87 g (P<0.01) and Lithuanian Black and White x Simental - 82 g (P<0.05). Similar results for purebreds were presented by the other authors (Berg, Butterfiield, 2003, Crews et. al., 2003).

No significant differences were observed in beef dry matter content (Table 2). Values varried from 24.7 % in Aubrac to 26.1 % in Lithuanian Red x Simental crossbred meat. That was 0.6 % lower and 0.7 % higher (P>0.05) respectively in comparison to the value of dry matter content in Lithuanian Black and White cattle meat. An exceptions were Lithuanian Red and Lithuanian Red x Charolais meat – theres‘ dry matter content was 1.1 and 0.9 % higher (P<0.05).

Table 1. **Weitgh and daily gain of different genotype of cattle**

Genotipe	Weight at 500 d. age, kg	Daily gain, g
LBW	478.5±10.32	960±7.16
LR	482.0±11.12	969±7.35
Simental	589.0±9.74	1078±12.44**
Charolais	647.0±12.16*	1128±14.52**
Aubrac	562.0±10.11	972±9.22
LBW x Simental	513.3±9.66	1042±11.23*
LR x Simental	512.0±8.93	1038±10.56*
LBW x Aubrac	497.0±10.36*	973±9.66
LR x Aubrac	493.0±9.89	962±8.99
LR x Charolais	524.0±11.23*	1047±12.10*

* – P< 0.05; ** – P<0.01

Table 2. **Dry matter, protein and intramuscular fat content in beef from different genotype of cattle**

Genotipe	Dry matter, %	Difference of dry matter content compered to the LBW, %	Protein, %	Difference of protein content compered to the LBW, %	Intramuscular fat content, %	Difference of intramuscular fat content compered to the LBW, %
LBW	25. 3±0.22	100	21.69±0.12	100	2.60±0.12	100
LR	26.4±0.12*	+1.1	22.68±0.08*	+ 0.99	2.71±0.18	+ 0.11
Simental	25.4±0.05	+ 0.1	22.10±0.09	+ 0.41	1.99±0.11**	– 0.63
Charolais	25.9±0.11	+ 0.6	23.50±0.15**	+ 1.81	1.31±0.13***	– 1.29
Aubrac	24.7±0.08	– 0.6	22.51±0.10	+ 0.82	1.12±0.09***	– 1.51
LBW x Simental	25.8±0.10	+ 0.5	22.03±0.09	+ 0.34	2.11±0.10**	– 0.49
LR x Simental	26.1±0.25	+ 0.8	22.70±0.07*	+ 1.1	2.19±0.17	– 0.43
LBW x Aubrac	24.9±0.14	– 0.4	22.01±0.11	+ 0.32	1.76±0.15**	– 0.86
LR x Aubrac	25.0±0.12	– 0.3	22.60±0.12*	+ 0.91	1.64±0.13**	– 0.99
LR x Charolais	26.2±0.10*	+ 0.9	23.30±0.11**	+ 1.61	1.99±0.20*	– 0.66

* – P< 0.05; ** – P<0.01; *** – P<0.001

Significant differences were observed in protein content. In purebreds group, highest content of proteins determinated in Charolais and Lithuanian Red meat and that was 1.81 (P<0.01) and 0.99 (P<0.05) % more than in Lithuanian Black and White bulls. In crossbreds group the highest content had Lithuanian Red and Charolais progenies (1,61 % (P<0.01)) and Lithuanian Red x Simental – 1.01 % (P<0.05) more than control. There was not found correlation between the dry matter and protein content in meat from both groups.

Intramuscular fat is located throughout skeletal muscle and is responsible for the marbling seen in certain cuts of beef. Intramuscular fat content values in *m. longissimus dorsi* from different genotypes of cattle varied from 1.10 to 2.72 % (Table 2).

The highest levels of intramuscular fat were found in Lithuanian Black and White and Lithuanian Red purebred bulls meat, the lowest, in Aubrac and Charolais purebred bulls meat (P<0.001). The fact that in French breeds the intramuscular fat content in the beef was found to be low, could apparently be explained by the tendency characteristic of this breed to accumulate less fat and to mature later. Therefore, the intramuscular fat of the 500 days old bulls has been limited.

Like most carcass traits, content of intramuscular fat is highly heritable, and respond well to selection. Significant breed differences exist in both beef groups (purebred and crossbred), but within-breed variation was also big. Results obtained from the purebred cattle are comparable with literature data (Moser, 2004, Sofos, 2008; Vandendriessche, 2008). There is no data on the tendency in intramuscular fat deposition of our studied Lithuanian beef breeds, but from the study results it can be stated that intramuscular fat level in the meat of the crossbreds is significantly lower (P<0.05 and P<0.01) than in the beef of Lithuanian Black and White purebred cattle. Apparently, a long term selection of purebreds for lean growth could have reduced intramuscular fat and marbling. The Angus beef breed has recently shown an increasing genetic trend for intramuscular adipose tissue deposition marbling, but most other beef breeds have shown little or no change in the past few decades (Moser, 2004, Wood et al., 2008). Breeding programs have selected faster-growing and more energy-efficient animals at the cost of intramuscular fat, marbling and tenderness (Hausman et al., 2009). Through the application of functional genomic tools, we will gain insight into how genetic components regulate adipogenesis, how they respond to environmental changes, and whether these changes affect the fat deposition and composition in meat (Basu et al., 2009). Modern husbandry practices, especially in countries such as United States that use the feedlots extensivey, have reduced the grow-out period to <24 month in order to save feed, labor and time; cattle are thus harvested prior to the late phase of fat deposition.

The mean values for the total cholesterol concentration in *M. longissimus dorsi* are given in Table 3. In beef the cholesterol contents ranged from 48.5 to 57.5 mg/ 100 g. The highest cholesterol level was determined in Lithuanian Black and White and Lithuanian Red purebreds. The ranges were lower 1.1-15.5 % for purebreds and 6.8-14.4 % for crossbreds compared with Lithuanian Black and White cattle.

Table 3. **Cholesterol content in beef from different genotype of cattle**

Bovine genotype	Cholesterol, mg/100 g	Cholesterol difference compared to the LBW, %
LBW	57.5±2.04	100
LR	56.7±1.63	-1.1
Simental	51.0±1.72*	-11.2
Charolais	49.7±1.23*	-13.3
Aubrac	48.5±2.60**	-15.5
LBW x Simental	53.3±1.77	-6.8
LR x Simental	53.0±2.89	-7.7
LBW x Aubrac	50.6±2.11*	-11.7
LR x Aubrac	49.2±2.07*	-14.4
LR x Charolais	52.3±2.33	-8.8

* – p<0.05; ** – p<0.01

The contents of cholesterol determined in this study were well within the results published in Germany for beef from 47 to 68 mg/ 100 g (Honikel and Arneth, 1996) and those analyzed by enzymatic method in Finland with an everage of 52 mg/100 g (Piironen et al., 2002). However, somewhat higher contents have also been published for beef longissimus muscles 63-67 mg/100 g (Swize et al., 1992). Some food composition tables contain partly somewhat higher values (USDA, 2000). In the USDA food composition data base, the range of beef cuts is 54-65 mg/100 g. Different methods for cholesterol determination, sampling and trimming of tissue may be reponsible for differences between the various published values (Chizzolini et al., 1999).

As reviewed by Chizzolini et al. (1999), the differences between breeds, or between sexes or in relation to various feeding regimens are also small in relation to their significance to dietary in take. Furthermore, the lack of correlation or weak correlation between the intramuscular fat and cholesterol content of meat is in line what has been found in previous studies (Honikel and Arneth, 1996). The data of our study (Table 2 and Table 3) demonstrate the same tendency: the correlations of cholesterol content and intramuscular fat content were weak (r<0.32).

Conclusions. The highest weight in comparison with Lithuanian Black and White cattle in the purebred group was registered in Charolais (+168.5 kg, P<0.05) and Simental (+110.5 kg, P<0.05), in crossbred group, Lithuanian Red x Charolais (+45.5 kg, P<0.05) and Lithuanian Black and White x Simental (+34.8 kg, P<0.05).

Comparable tendency was observed in daily gain: for Charolais it was 168 g (P<0.01), for Simental, 118 g (P<0.05), for Lithuanian Red x Charolais, 87 g (P<0.01) and for Lithuanian Black and White x Simental it was 82 g (P<0.05).

Dry matter content in beef varried from 24.7 % in Aubrac to 26.1 % in Lithuanian Red x Simental crossbred meat. Significant differences were observed in protein content, but there was no correlation found between the dry matter and protein content in the beef from both groups.

In beef the cholesterol contents ranged from 48.5 to 57.5 mg/ 100 g. The ranges were lower 1.1-15.5 % for purebreds and 6.8-14.4 % for crossbreds compared to Lithuanian Black and White cows. The highest cholesterol level was determined in Lithuanian Black and White and Lithuanian Red purebreds. However, significant differences in cholesterol level were observed in the beef from Lithuanian Black and White x Aubrac and Lithuanian Red x Aubrac: 11.7 and 14.4 % ($p<0.05$), respectively. The weak correlations between the cholesterol content and intramuscular fat content were determined ($r<0.32$).

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