THE INFLUENCE OF CATTLE BREED ON NUTRITIONAL VALUE AND MINERAL CONTENT OF MEAT

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Abstract. The aim of this study was to determine the mineral content in various breeds' cattle meat and its correlation with chemical meat quality indices. The concentrations of natrium, magnesium, calcium, nickel, copper, zinc, barium, selenium, and iron were determined by inductively coupled plasma mass spectrometry (ICP–MS) after microwave digestion. Different concentrations were found in meat of different cattle breeds and were notable for zinc, cuprum, calcium and barium. The highest coefficients of variation were found for natrium and they were not statistically significant. Statistically significant differences of chemical composition (dry matter, proteins, intramuscular fat, total ash) were found in different breeds' cattle meat ($P < 0.05 – P < 0.001$). A positive correlation between the amount of Fe and the amount of proteins and a negative correlation between the amount of Na, Mg, Cu and the amount of ash in the meat were determined. In conclusion, a precise determination of chemical content is very important for the essentials of human nutrition. Therefore, it is very important that the data of nutrients be regularly renewed and possible changes be observed with available data.

Keywords: nutritional value, mineral content, cattle, breed, meat

Introduction

The consumers' interest in the nutritional value of foods which may promote health and prevent diseases is increasing (Brugiapaglia et al., 2014). The sensory, health-related and nutritional properties are the most important motivators for liking and purchasing of meat (Muchenje et al., 2009). Lean red meat has a high nutritional value, being an important source of high quality protein, essential amino acids, vitamins (A, B6, B12, D) and minerals, including iron, zinc, cooper and selenium (Daley et al., 2010; Brugiapaglia et al., 2014; Jensen et al., 2014).

Today, mineral deficiencies in humans are common worldwide. Consumption of beef can be a good way to respond qualitatively and quantitatively to the mineral requirements of human nutrition. Red meat is a major source of minerals for the human diet and provides essential minerals of high bioavailability to human nutrition. However, the mineral composition and nutritional value of beef changes with breed and age of animals, muscles type and feeding practices, geographical site of rearing and processing (Muchenje et al., 2008; Cabrera et al., 2010). Breed is an important factor that can influence the characteristics of the raw muscle tissue and hence of the finished product (Albertí et al., 2008; Christensen et al., 2011). Meat quality and mineral content of different beef breeds have been evaluated in several studies (Chambaz et al 2003; Bureš et al., 2006; Vieira et al., 2007; Miranda et al., 2009; Cabrera et al., 2010; Christensen et al., 2011; Pesonen et al., 2012; Prieto et al., 2010; Xiangxue et al., 2012), but the material of meat nutritional value and mineral content after their standardised feeding, keeping and stunning conditions are very limited.

Considering meat as an essential component of the human diet, it is important to explore nutritional value and mineral concentrations in different breed's meat. Besides the relevance of mineral content in meat for human nutrition, the investigation of the effects of mineral levels on meat quality is also important. Mineral content in beef can affect not only nutritional values but also meat quality traits. The aim of the research was to determine the mineral content in various breeds' cattle meat and its correlation with chemical meat quality indices.

Methods and materials

Scientific research was performed at the Laboratory of Meat Characteristics and Quality Assessment of the Animal Husbandry Department of the Lithuanian University of Health Sciences Veterinary Academy and State Food and Veterinary Service Institute of Risk Assessment. Control cattle growth was performed at UAB Šilutės veislininkystė, in standardised feeding and keeping conditions. The study was carried out with bulls from 120 to 500 days of age. The hogs were kept bounded, non-neutered. The hogs were given herbaceous forage *ad libitum* and 1 kg of combinative forage for 100 kg of animal's body weight. The cattle were slaughtered at 500 days of age. Control slaughtering was performed after 24 hours of cattle starvation. The cattle were not given water 3 hours before slaughtering.

Ten samples of meat from 4 cattle breeds were taken for the analysis: angus (AN), simmental (SI), charolais (CH), and limousin (LI). The samples for the analysis of chemical composition and technological qualities of cattle meat were taken 24 hours after carcass meat cooling from *musculus longissimus dorsi*, beside the last 2 ribs, and the amount of the samples taken was 500–550 g. The samples were kept in a refrigerator at +4°C temperature.

For estimating the chemical composition of cattle meat according to certified methodology, the following parameters were determined:

- dry matter by drying meat samples until constant mass with automatic dry matter scales (Scaltec SM – 1);
- the amount of proteins by the Kjeldahl's method (King-Brink, Sebranek, 1993);

- the amount of fat by the Soxhlet method (ISO 1443:1973 Meat and meat products determination of total fat content);
- the amount of ash by roasting the organic matter of meat at 600°C–800°C temperature (ISO 936:1998 Meat and meat products determination of total ash).

The amount of mineral content in cattle meat was estimated at the State Food and Veterinary Service Institute of Risk Assessment, laboratory of chemical research, 48 hours after the carcass meat had been cooled. The amount of the samples (10 g per 10 samples of meat from each 4 cattle breeds) was taken from *musculus longissimus dorsi* and held in a refrigerator at +4°C temperature.

For estimating the amount of mineral content in cattle meat according to certified methodology, the following procedures were performed:

- mineralisation of the samples with microwave system ETHOS 900 (by European standard LST EN 13805:2002. Processed food. Microelement evaluation. Mineralization in high pressure);
- evaluation of minerals with inductively coupled plasma mass spectrometry (ICP–MS) (by LST EN 15763:2010. Processed food. Microelement evaluation);
- mineral content was estimated (mg/kg): natrium (Na), magnesium (Mg), calcium (Ca), nickel (Ni), copper (Cu), zinc (Zn), barium (Ba), selenium (Se), and iron (Fe) (the amount of Fe was evaluated using the dynamic reaction cell (DRC) mode, as well as emitted methane gas, which eliminates interferences).

The data of analysis were processed with statistical package R, version 2.0.1. Excel spreadsheet tools of data analysis were used for statistical analysis. The influence of genetic factors (in percent) was evaluated by the method of dispersive analysis (ANOVA). Coefficient of correlation (r) was calculated. Disparities were considered to be reliable when $P < 0.05$.

Results and discussion

The meat of beef plays an important role in the human nutrition as a source of full-rate proteins, irreplaceable amino acids, fat-soluble vitamins, macro- and microelements and other important components of nutrition (Garmienė et al., 2010). Chemical meat quality indices of various cattle are given in Table 1. From the data given in the table, it can be seen that the amounts of dry matter and proteins in *musculus longissimus dorsi* of various breeds' cattle were slightly different. The biggest amount of dry matter and proteins was determined in CH cattle breed's meat, the least amount in SI cattle breed's meat, and the difference reached 1.94% ($P > 0.05$) and 1.28%. On the contrary, Bureš et al. (2006) reported that the least amount of dry matter was found in CH cattle breed's meat. The results of the amount of protein in various breeds' cattle meat are in accordance with the conclusion of Wheeler et al. (2005).

Table 1. **Chemical meat quality indices of various cattle breeds**

Index, %	Genotype			
	AN	SI	CH	LI
Dry matter	24.50±0.30	23.88±0.62*	25.82±0.61*	25.16±0.31
Proteins	21.41±0.30	21.09±0.64	22.37±0.61	21.80±0.18
Fat	1.92±0.09	1.69±0.25*	2.40±0.02*	2.25±0.25
Ash	1.14±0.02***	1.10±0.02	1.04±0.02***	1.11±0.01
* – $P < 0.05$; ** – $P < 0.01$; *** – $P < 0.001$				

Fat increases meat's energetic value, supplements it with soluble in fat vitamins and, besides that, supports the assimilation of these vitamins during the digestion process (Liutkevičius et al., 2009). CH cattle breed's meat had the least amount of intermuscular fat, LI cattle breed's meat had it less by 0.15%, SI cattle breed's meat contained the least amount of fat, compared with CH, and the difference reached 0.71% ($P > 0.05$). In contrast to the findings obtained in this study, Gregory, Wheeler and Jukna reported different results: the biggest amount of intramuscular fat was found in AN cattle breed's meat (Gregory et al., 1994; Wheeler et al., 2005., Jukna et al., 2013). The results of the studies might differ because of different cattle growth conditions and slaughtering age.

Variation of the amount of ash in various cattle breeds' meat was minor. It varied from 1.04% to 1.14% ($P < 0.001$). AN cattle breed's meat had the biggest amount of it, CH had the least, and the difference reached 0.1% ($P < 0.001$). A difference of only 0.01% was observed between the amount of ash in *musculus longissimus dorsi* of SI and LI.

Many minerals that meat contains are vital for a human organism, as they participate in its various significant functions. A decreased biological accessibility of mineral elements might determine organisms' functional disorders (Melo et al., 2008). The amounts of different mineral elements in different breeds' cattle meat are given in Table 2. From the data given, it can be seen that the amounts of various minerals in the meat of different cattle breeds were not equal.

The biggest amount of Na was found in the meat of SI, the least amount was found in pure breed AN breed's cattle meat, and the difference reached 10.29% or 53.133 mg/kg. However, the data of average square deviation values of the amount of Na in various breeds' cattle meat were not statistically significant.

The biggest amount of Mg was found in CH, the least in LI breed's cattle meat, and the difference constituted 17.6% or 51.741 mg/kg ($P < 0.001$). A similar amount of Mg was estimated in SI and CH breeds' cattle meat, and the difference between both constituted only 1.32% or 3.893 mg/kg.

LI breed's cattle meat was distinguished for having the least amount of minerals Ca and Zn. Comparing the amounts of the same minerals in *musculus longissimus dorsi* of SI breed's cattle meat (that had the biggest amounts of it), the difference constituted 23.78% or 14.013 mg/kg and 23.62% or 7.958 mg/kg, respectively. The amount of these minerals was estimated to be similar in AN, SI and CH meat. Comparable findings are reported by Mahecha and Hollo (Hollo et al., 2008; Mahecha et al., 2009).

There were no considerable inter-breed differences while estimating the amount of Se in cattle meat. The amount of Se was almost equal in SI, CH and LI breeds' cattle meat, compared with the meat of AN breed's cattle that was distinguished for having the biggest amount of Se, and the difference constituted 12.5% or 0.007 mg/kg. Compared with the results of Mahecha et al. (2009), the mean Se concentration in cattle meat in this study was lower. A bigger influence of genotype is seen according to the amounts of Cu and Ba in various cattle breeds' meat. In comparison with other breeds, the lowest amount of Cu and Ba was determined in LI breed's cattle meat, and the biggest in CH breed's meat. Compared with the results of Hollo (2008), the mean Cu concentration in cattle meat in this study was higher.

While estimating the amount of Ni in cattle's *musculus longissimus dorsi,* the biggest difference was established between CH and LI breeds' cattle meat, and it reached 17.1% or 0.041 mg/kg, whereas the least difference observed between CH and SI reached 4.49% or 0.011 mg/kg.

SI breed's cattle meat had the biggest amount of Fe, and the difference reached 3.86% or 0.773 mg/kg compared with CH, and 7.44% or 1.496 mg/kg compared with AN. The difference between it and LI breed's cattle meat, which had the least amount of Fe, constituted 10.01% or 2.007 mg/kg. These data are statistically non-significant. The results of this study are in accordance with the conclusion of Chambaz et al. (2003) and Golze et al. (2013).

Table 2. **Mineral content of different breeds' cattle meat, mg/kg**

Mineral	Genotype			
	AN	SI	CH	LI
Na	463.126±18.488	516.259±24.900	495.473±21.315	490.886±18.293
Mg	274.484±5.893	290.085±5.414	293.980±6.491***	242.239±4.972***
Ca	57.802±1.030	58.921±1.859	58.271±0.931	44.908±1.396
Zn	30.841±1.483	33.696±1.200	31.679±2.140	25.738±0.493
Se	0.056±0.012	0.049±0.003	0.049±0.002	0.050±0.003
Cu	0.640±0.039	0.690±0.039	0.748±0.055*	0.454±0.016*
Ni	0.221±0.035	0.234±0.041	0.245±0.031	0.203±0.044
Fe	18.551±0.998	20.047±2.001	19.274±1.418	18.040±0.586
Ba	0.042±0.007	0.034±0.007	0.044±0.004*	0.024±0.003*
* – $P < 0.05$; ** – $P < 0.01$; *** – $P < 0.001$				

Influence of genotype upon chemical meat quality indices in cattle's *musculus longissimus dorsi* is given in Table 3. The biggest influence of cattle genotype was estimated for the amount of ash ($P < 0.01$), dry matter ($P < 0.05$) and intermuscular fat ($P < 0.05$). The least influence of genotype was estimated for the amount of proteins, although the data was statistically non-significant.

Table 3. **Influence of genotype upon chemical meat quality indices in cattle's *musculus longissimus dorsi***

Index	Dry matter	Proteins	Fat	Ash
Influence, %.	25.32*	13.26	22.24*	39.47**
* – $P < 0.05$; ** – $P < 0.01$; *** – $P < 0.001$				

Influence of genotype upon the amount of minerals in cattle's *musculus longissimus dorsi* was not equal (Table 4). Genotype had the biggest influence upon minerals Ca and Mg ($P < 0.05$), Cu and Zn ($P < 0.01$), whereas the least and statistically non-significant influence was observed upon the amount of Se, Ni, Fe, Na and Ba.

Correlation of cattle mineral content and indices of meat quality. Modern meat production techniques aim to increase chemical composition and mineral content in meat, but these characteristics are not always positively correlated. The more Na the meat contains, the less ash ($P < 0.05$) and proteins and the more fat it has. When the amount of Mg in meat is lower, the amount of ash increases. The amount of Ca negatively correlated with the amount of dry matter, and Zn content negatively correlated with the amount of intramuscular fat. The correlation of minerals Se and Ba with indices of meat quality was low. A negative and statistically significant correlation between Cu and the amount of ash ($P < 0.05$) and positive with the amount of proteins in the meat were estimated. When various cattle breeds' meat contains more Fe, the amount of proteins increases, although the amounts of fat and ash decrease (Table 5).

Table 4. **Influence of genotype upon the amount of minerals in cattle's *musculus longissimus dorsi***

Mineral	Influence, %.
Na	11.98
Mg	62.07**
Ca	72.94
Zn	38.69**
Se	1.89
Cu	52.78*
Ni	1.91
Fe	4.77
Ba	16.93
* – P < 0.05; ** – P < 0.01; *** – P < 0.001	

Table 5. **The correlation of mineral content and quality indices of cattle's *musculus longissimus dorsi***

Mineral	Parameter			
	Dry matter	Proteins	Fat	Ash
Na	-0.103	-0.209	0.235	-0.340*
Mg	-0.098	-0.080	-0.031	-0.305
Ca	-0.203	-0.154	-0.145	-0.124
Zn	-0.139	-0.015	-0.291	-0.106
Se	-0.010	-0.035	0.048	0.025
Cu	-0.010	0.021	-0.032	-0.385*
Ni	-0.080	-0.031	-0.099	-0.252
Fe	0.161	0.310	-0.254	-0.267
Ba	-0.071	-0.017	-0.136	0.031
* – P < 0.05; ** – P < 0.01; *** – P < 0.001				

Conclusions

1. There were statistically significant differences in dry matter, protein, intramuscular fat and general ash (P < 0.05 – P < 0.001) in the meat of analysed breeds' cattle.

2. A breed has influence on the amount of minerals in the meat of brood cattle. Simmental breed's cattle meat was distinguished for having the biggest amount of Na, Ca, Zn and Fe, charolais for Mg (P < 0.001), Cu (P < 0.05), Ni and Ba (P<0.05), and angus breed's cattle meat had the biggest amount of Se. Except for Na and Se, limousin breed's cattle meat had the least amounts of minerals.

3. A dispersive analysis of the data showed that the biggest influence of genotype upon the amount of minerals in various breeds' beef cattle meat was determined for minerals Ca, Mg (P < 0.01), Cu (P < 0.05) and Zn (P < 0.01).

4. Estimation of correlation between the mineral content and meat quality indices of analysed cattle breeds' meat highlighted a positive correlation between the amount of Fe and the amount of proteins in the meat and a negative correlation between the amount of Na, Mg, Cu and the amount of ash.

References

1. Albertí P., Panea B., Sañudo C., Olleta J. L., Ripoll G., Ertbjerg P. Live weight, body size and carcass characteristics of young bulls of fifteen European breeds. Livestock Science. 2008. T. 114. P.19−30.

2. Brugiapaglia A., Lussiana C., Destefanis G. Fatty acid profile and cholesterol content of beef at retail of Piemontese, Limousin and Friesian breeds. Meat Science. 2014. T. 96. P. 568–573.

3. Bureš D., Bartoň L, Zahrádková R., Teslík V., Krejčová M. Chemical composition, sensory characteristics, and fatty acid profile of muscle from Aberdeen Angus, Charolais, Simmental, and Hereford bulls. Czech J. Anim. Sci. 2006. T. 51(7). P. 279–284.

4. Cabrera M.C, Ramos A., Saadoun A., Brito G. Selenium, copper, zinc, iron and manganese content of seven meat cuts from Hereford and Braford steers fed pasture in Uruguay. Meat Science. 2010. T. 84. P. 518–528.

5. Chambaz A., Scheeder M. R. L, Kreuzer M., Dufey P. A. Meat quality of Angus, Simmental, Charolais and Limousin steers compared at the same intramuscular fat content. Meat science. 2003. T. 63 (4). P. 491–500.

6. Christensen L., Ertbjerg P., Aaslyng M.D., Christensen M. Effect of prolonged heat treatment from 48°C to 63°C on toughness, cooking loss and color of pork. Meat Science. 2011. T. 88. P. 280–285.

7. Christensen M., Ertbjerg P., Failla S., Sañudo C., Richardson R., Nute G.F, José L., Olleta C., Panea B., Albertí P., Juárez M., Hocquette J.F., Williams J. Relationship between collagen characteristics, lipid content and raw and cooked texture of meat from young bulls of fifteen European breeds. Meat Science. 2011. T. 87. P. 61–65.

8. Daley C.A., Abbott A., Doyle P.S., Nader G.A., Larson S. A review of fatty acid profiles and antioxidant content in grass-feed and grain-fed beef. Nutrition Journal. 2010. T. 9. P.1–12.

9. Garmienė G., Jasutienė I., Zaborskienė G., Mieželienė A., Alenčikienė G., Miliauskienė I. Lietuvos rinkoje parduodamos kiaulienos nugarinės kai kurių rodiklių palyginimas. Veterinarija ir zootechnika. 2010. T. 52 (74). P. 21-28.

10. Golze M. Fleisch – ein Stuck Lebenskraft. Fleisehrinder. 2013. T. 4, P.18-20.

11. Gregory K.E., Cundi L.V., Koch M., Dikeman M.E, Koohmaraie M. Breed effects and retained heterosis for growth, carcass, and meat traits in advanced generations of composite populations of beef cattle. Journal of animal science. 1994. T. 72. P. 833-850.

12. Hollo G., Ender K.†, Loki K., Sergi J., Hollo I., Nuernberg K. Carcass characteristics and meat quality of Hungarian Simmental young bulls fed different forage to concentrate ratios with or without linseed supplementation. Arch. Tierz, Dummerstorf. 2008. T. 51 (6). P. 517-530.

13. Jensen I.J., Dort J., Eilertsen K.E. Proximate composition, antihypertensive and antioxidative properties of the semimembranosus muscle from pork and beef after cooking and in vitro digestion Meat Science. 2014. T. 96. P. 916–921.

14. Jukna V., Jukna Č., Pečiulaitienė N., Prusevičius V. Lietuvoje veisiamų mėsinių galvijų ir jų mišrūnų mėsos kokybė. Veterinarija ir zootechnika. 2013. T. 61 (83). P. 30-35.

15. King-Brink M., Sebranek J.G. Combustion. Method for Determination of Crude Protein in Meat and Meat Products: Collaborative Study. Ibid. 1993. T. 76. P. 787–793.

16. Liutkevičius A., Speičienė V., Mieželienė A., Alenčikienė G. Įprastomis sąlygomis užaugintų mėsinių, pieninių bei ekologiškai užaugintų pieninių galvijų mėsos kokybė. Maisto chemija ir technologija. 2009. T. 43(2). P. 47-56.

17. Mahechaa L., Nuernberg K., Nuernberg G., Ender K., Hagemannd E., Dannenberger D. Effects of diet and storage on fatty acid profile, micronutrients and quality of muscle from German Simmental bulls. Meat Science. 2009. T. 82. P. 365–371.

18. Melø R., Gellein K., Evje L., Syversen T. Minerals and trace elements in commercial infant food. Food and Chemical Toxicology. 2008. T. 46. P. 3339–3342.

19. Miranda B.J.L, Blanco-Penedo I., López-Lamas C., Merino A., López-Alonso M. Metal accumulation in cattle raised in a serpentine-soil area: Relationship between metal concentrations in soil, forage and animal tissues. Journal of Trace Elements in Medicine and Biology. 2009. T. 23. P. 231-238.

20. Muchenje V., Dzama K., Chimonyo M., Strydom P., Hugo A., Raats J. Some biochemical aspects pertaining to beef eating quality and consumer health: A review. Food Chemistry. 2009. T. 112 (2). P. 279-289.

21. Pesonen M., Honkavaara M., Huuskonen A. Effect of breed on production, carcass traits and meat quality of Aberdeen Angus, Limousin and Aberdeen Angus x Limousin bulls offered a grass silage-brain-based diet. Agricultural and food science. 2012. T. 21. P. 361-369.

22. Prieto N., Navajas E.A, Richardson R.I., Ross D.W., Hyslop J.J., Simm G., Roehe R. Predicting beef cuts composition, fatty acids and meat quality characteristics by spiral computed tomography. Meat Science. 2010. T. 86. P. 770–779.

23. Vieira C., Cerdeño A., Seffano E., Lavín P., Mantecón A.R. Breed and ageing extent on carcass and meat quality of beef from adult steers (oxen). Livestock Science. 2007. T. 107. P. 62−69.

24. Wheeler T.L, Cundiff L.V, Shackelford S.D, Koohmaraie M. Characterization of biological types of cattle (Cycle VII): Carcass, yield, and longissimus palatability traits. Journal of animal science. 2005. T. 83. P. 196-207.

25. Xiangxue X., Qingxiang M., Zhengliang C., Liping R. Effect of cattle breed on meat quality, muscle fiber charasteristics, lipid oxidation and fatty acids in China. Asian-Aust. J. Anim. Sci. 2012. T. 25(6). P. 824-831.

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