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Amino Acid Levels in Muscle Tissue of Eight Meat Cattle Breeds

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ABSTRACT

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Ten clinically healthy bulls equal in weight were chosen from eight meat cattle breeds maintained in the same geographical conditions using the extensive grazing method. After slaughtering, muscle tissue samples were taken from the *musculus longissimus* and *pars thoracis*, and dry matter, nitrogenous substances, fat, and the levels of essential (EAAs) and non-essential (NEAAs) amino acids were determined. Significant differences were found between the monitored genotypes in the contents of dry matter, nitrogenous substances, fat, EAAs, and NEAAs ($P \leq 0.05$). The highest concentrations of nitrogenous substances in muscle tissue were detected in the Limousine breed and the lowest in the Aberdeen Angus breed; the highest fat content was found in Aberdeen Angus and the lowest in Galloway. Out of the total sum of EAAs, the highest percentage in the dry matter of muscle tissue in all genotypes was found for Lys (8.8–10.4%), the lowest percentage was found for Met (2.4–2.9%). The value of Thr was approximately 4.6, Val 5.1, Ile 4.8, Leu 8.2, Phe 4.1, His 4.2, and Arg 8.0%. Significant differences ($P \leq 0.05$) between the monitored breeds were found in all EAAs, except for Val and Leu. Regarding NEAAs, out of the total protein, the highest percentage was found for Glu (13.9–15.1%). Conversely, the lowest values were detected for Ser (3.8–4.1%) and Tyr (3.8–4.4%). The values of other NEAAs were approximately 9.3 for Asp, 4.0 for Ser, 5.3 for Pro, 5.5 for Gly, and 6.1% for Ala. Significant differences ($P \leq 0.05$) were found between the monitored genotypes in all NEAAs except for Pro and Ala. In the dry matter of muscle tissue, out of the total protein, the sum of EAAs ranged from 50.6 (Meat Simmental) to 52.0% (Limousine), and NEAAs ranged from 48.0 (Limousine) to 49.4% (Meat Simmental). Apart from its effect on the biological value of meat, representation of individual amino acids is important to enhance its taste or smell.

Keywords: meat cattle breeds; *musculus longissimus dorsi*; dry matter; protein; fat; essential and non-essential amino acids

List of abbreviations: EAAs = essential amino acids, NEAAs = non-essential amino acids, Asp = aspartic acid, Thr = threonine, Ser = serine, Glu = glutamic acid, Pro = proline, Gly = glycine, Ala = alanine, Val = valine, Met = methionine, Ile = isoleucine, Leu = leucine, Tyr = tyrosine, Phe = phenylalanine, His = histidine, Lys = lysine, Arg = arginine, AA = Aberdeen Angus, BA = Blonde d'Aquitaine, Lim = Limousine, Char = Charolais, Gas = Gasconne, MS = Meat Simmental, Sal = Salers, Gall = Galloway

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The levels of amino acids (AAs) in the muscle tissue of animals are relatively constant. Partial differences are mentioned, for example among breeds (Hollo et al. 2007), sexes (Hollo et al. 2001; Koutsidis et al. 2008), and ages, and they can also be influenced by nutrition (Koutsidis et al. 2008). Nutrition is one of the major external factors affecting not only the intensity of production, but also the quality of the product – meat (Fujimura and Kadowaki 2006). The knowledge of the content of AAs in the meat of food animals also contributes to better knowledge of their needs (Stilborn et al. 1997), which are derived from the percentage of AAs in the body (Saunders et al. 1977).

Twenty-two AAs are necessary for creating proteins in the body; some of them can be synthesized – the non-essential amino acids (NEAAs), while essential amino acids (EAAs) cannot be synthesized in the necessary amount (Applegate and Angel 2008). From EAAs, lysine and threonine cannot be created by animals at all because animals do not have the necessary transaminases to synthesize them. Essential AAs are also those that are necessary for the body and can be synthesized in the body but not in sufficient amounts. These are tryptophan, histidine, phenylalanine, leucine, isoleucine, methionine, valine, and arginine. Their synthesis is, however, a theoretical rather than practical possibility because feed does not contain the appropriate keto acids necessary to create them. Semi-essential AAs can be synthesized in the body, but only some of the indispensable amino acids – cysteine out of methionine and tyrosine out of phenylalanine – are commonly synthesized. While the need for phenylalanine can only be solved by phenylalanine itself, the need for tyrosine can be solved by tyrosine or phenylalanine. In the case of a lack of cysteine in feed, the animal can create cysteine out of methionine, but methionine cannot be created from cysteine. The quantity of EAAs is significantly larger in females than in males (Hollo et al. 2001).

Within cattle breeding oriented to meat production, twelve modern meat breeds have been introduced and recognized in the Czech Republic. They are Aberdeen Angus, Belgian Blue-White, Blonde d'Aquitaine, Galloway, Gasconne, Hereford, Highland, Charolais, Limousine, Meat Simmental, Piemontese, and Salers. The individual genotypes of meat cattle have characteristic properties.

Literature data regarding the percentage of AAs in the body are rare. Some studies focused on the amino acid composition in other species (e.g. Strakova et al. 2015; Tumova et al. 2015); however, studies for the modern meat cattle breeds are sporadic (Subrt et al. 2002; Stilborn et al. 1997, 2010). The genetic potential of cattle has increased in recent years, as have the higher efficiency results in changes in the need for amino acids (Salehifar et al. 2012). Meat has a high nutritional value due to the significant content of quality proteins and low fat. However, there is not enough exact knowledge for these statements, which concerns, in particular, the amino acid composition of meat. The papers published by Subrt et al. (2002) and Hollo et al. (2001, 2007) are some of the few available papers that address the composition of AAs of muscle tissue in detail.

The composition and quality of beef are influenced by a number of factors (Hanzelkova et al. 2011) such as the genotype, age at the time of slaughter, and sex; the finishing feeding treatment can be considered a significant factor. Several papers addressed the chemical composition of various parts of the body, slaughter efficiency, and the influence of sex on efficiency indicators. The representation of certain AAs significantly acts on the sensory properties of products (Fujimura and Kadowaki 2006).

As stated by Baker (1997), the need for AAs can be affected by a number of factors, including protein level, energy level, and the presence of protease inhibitors, environmental factors such as crowding, the space at feeding points, heat and cold, changes in health conditions, genetic factors, sex, and genes for meat leanness or fat content.

The aim of this paper was to acquire data on the percentages of dry matter, nitrogenous substances, fat, and essential and non-essential amino acids in muscle tissue in bulls of modern meat breeds, approximately of the same age and weight, and to compare the possible differences. Papers that would compare the above-mentioned values in meat breeds in the range presented here are sporadic in the available literature.

MATERIAL AND METHODS

The monitored animals were from eight cattle breeds recognized in the Czech Republic: Aberdeen Angus (AA), Blonde d'Aquitaine (BA), Li-mousine (Lim), Charolais (Char), Gasconne (Gas), Meat Sim-

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mental (MS), Salers (Sal), and Galloway (Gall). The animals of the mentioned breeds were maintained in the same area of Southern Bohemia (Křišťanov) using the extensive grazing method. Nutrition was based on the intake of grass. The winter feed ration consisted of haylage, hay, and straw.

At the age of 16 to 18 months, 10 clinically healthy bulls equal in weight were chosen from each cattle breed. After slaughtering, a 500 g sample of muscle tissue was taken from the *musculus longissimus* and *pars thoracis*. Samples were taken from the left half of the body, from the area of the 1st to 10th dorsal vertebra, cooled, frozen, and gradually analyzed.

In the laboratory, dry matter, nitrogenous substances, fat, and amino acids were determined (AOAC 2006). The muscle tissue sample was homogenized and dried at 105°C under the prescribed conditions, and the dry matter was determined. The nitrogen content was determined using the Kjeldahl method on the Buchi analyzer (Centec automatika, Prague, Czech Republic*)* and the content of nitrogenous substances (crude protein) was calculated by multiplying the values of nitrogen by the coefficient 6.25. Fat was determined using an ANKOM^{XT10} Fat Analyzer (O.K. SERVIS BioPro, Prague, Czech Republic). The content of amino acids was determined from the sample dry matter after the acid hydrolysis of muscle tissue in 6N HCl at 110°C for a period of 24 h by the automatic amino acid analyzer AAA 400 (Ingos a.s., Prague, Czech Republic), based on the colour reaction of amino acids with the oxidation agent ninhydrin. The following amino acids were determined: aspartic acid (Asp), threonine (Thr), serine (Ser), glutamic acid (Glu), proline (Pro), glycine (Gly), alanine (Ala), valine (Val), methionine (Met), isoleucine (Ile), leucine (Leu), tyrosine (Tyr), phenylalanine (Phe), histidine (His), lysine (Lys), and arginine (Arg).

With regard to the fact that in muscle tissue there are variable values of fat and the content of water in the muscle tissue changes and is affected by a number of factors, AA concentrations were measured in the dry matter of muscle tissue, which gives a more accurate and mutually comparable result.

The results were processed using mathematical-statistical methods with the Unistat program, Version 5.6 for MS Excel. The average values and their differences were evaluated by multiple comparisons using the Tukey's HSD test at the level of significance $P \leq 0.05$. The correlation coefficient was calculated. Each indicator is shown by the average of values ($\bar{x}$) and standard deviation (± SD).

RESULTS AND DISCUSSION

The aim of the paper was to obtain knowledge of the representation of basic nutrients (dry matter, nitrogenous substances, and fat) and essential and non-essential amino acids in the muscle tissue of bulls of modern meat breeds and to compare the possible differences. The mentioned parameters predetermine the biological, dietetic, and culinary values of meat. Data on this subject are not frequent and concern the present meat breeds of cattle only sporadically. The lowest mean value of the dry matter in the muscle tissue (Table 1) was found in Gall (245.2 ± 17.65 g/kg), and it was significantly different from the mean values for AA, BA, Char, Gas, MS, and Sal ($P \leq 0.05$). The highest mean values of the dry matter were found in AA (277.6 ± 11.63 g/kg) and BA (277.3 ± 22.28 g/kg). Significant differences in the content of dry matter were also found between AA and Lim, as well as BA and Lim ($P \leq 0.05$). The concentration of fat ranged from 68.5 ± 18.81 (Gall) to 171.6 ± 43.30 g/kg (AA); significant differences in fat content were found between AA and BA, Gall and AA, and AA and Lim ($P \leq 0.05$). The levels of nitrogenous substances ranged from 791.1 ± 45.84 (AA) to 897.6 ± 60.36 g/kg (Lim). Significant differences in the content of nitrogenous substances in dry matter were found between genotypes Lim and AA, Gas and AA ($P \leq 0.05$), and Lim and Ba ($P \leq 0.05$). Subrt et al. (2002) did not find significant differences in total protein content among other monitored bull breeds. Additionally, Ito et al. (2012) did not find differences with regard to moisture, ash, crude protein, total lipids, and total cholesterol between four genetic groups of young bulls. In full agreement with the knowledge of Subrt et al. (2002), we found the highest total protein values in Lim (897.6 g/kg) and the lowest in AA (791.1 g/kg), which may be associated with the content of intramuscular fat in the muscle tissue of these genotypes (Lim 80.4 and AA 171.6 g/kg). This trend is also confirmed by the significant negative correlation coefficient ($r = -0.821$; $P < 0.05$) between the contents of total protein and fat in the muscle tissue.

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Table 1. Mean values (in g/kg) of dry matter (DM), nitrogenous substances (NS), and fat (F) in the muscle tissue of meat cattle breeds (n = 10), NS and F are expressed on a dry matter basis

Breed $\bar{x}$	AA	BA	Lim	Char	Gas	MS	Sal	Gall
DM	277.6 ± 11.63^{b}	277.3 ± 22.28^{b}	251.1 ± 13.27^{ac}	268.0 ± 14.86^{bc}	269.7 ± 8.38^{bc}	271.5 ± 7.75^{bc}	267.5 ± 24.00^{bc}	245.2 ± 17.65^{a}
NS	791.1 ± 45.84^{ac}	822.0 ± 72.07^{ac}	897.6 ± 60.36^{b}	858.1 ± 57.66^{ac}	868.3 ± 25.09^{bc}	849.4 ± 25.80^{ac}	835.7 ± 60.60^{ac}	858.9 ± 42.62^{ac}
F	171.6 ± 43.30^{b}	145.0 ± 81.07^{bc}	80.4 ± 59.11^{ac}	107.5 ± 58.14$^{a–c}$	108.8 ± 23.58$^{a–c}$	129.7 ± 30.31$^{a–c}$	118.9 ± 58.29$^{a–c}$	68.5 ± 18.81^{ac}

AA = Aberdeen Angus, BA = Blonde d'Aquitaine, Lim = Limousine, Char = Charolais, Gas = Gasconne cattle, MS = Meat Simmental, Sal = Salers, Gall = Galloway cattle

$^{a–c}$means within the same row with different superscripts significantly differ ($P \leq 0.05$)

Table 2. Mean values (in g/kg) of essential amino acids in the meat cattle breeds muscle tissue dry matter (n = 10)

Breed $\bar{x}$	AA	BA	Lim	Char	Gas	MS	Sal	Gall
Thr	34.0 ± 4.50	35.3 ± 4.24	37.0 ± 2.73	35.6 ± 4.73	39.3 ± 1.78	36.6 ± 2.63	36.5 ± 3.17	373 ± 2.32
Val	37.9 ± 4.44^{ac}	39.2 ± 4.36$^{a–c}$	41.8 ± 3.13$^{a–c}$	40.0 ± 4.59$^{a–c}$	44.3 ± 1.28^{bc}	41.0 ± 3.00^{ab}	38.4 ± 7.15$^{a–c}$	41.3 ± 2.38$^{a–c}$
Met	18.2 ± 2.50^{acd}	19.0 ± 3.27$^{a–d}$	21.6 ± 2.26$^{a–d}$	19.3 ± 2.82$^{a–d}$	25.1 ± 1.29^{b}	21.6 ± 2.26$^{a–d}$	22.6 ± 2.84$^{a–d}$	21.6 ± 2.13$^{a–d}$
Ile	35.5 ± 4.06	37.4 ± 4.32	39.8 ± 3.43	38.1 ± 4.72	40.3 ± 1.60	38.3 ± 2.92	36.9 ± 5.17	38.5 ± 2.23
Leu	61.3 ± 7.61	64.1 ± 7.34	68.6 ± 5.40	65.8 ± 7.86	70.1 ± 3.13	66.7 ± 5.12	65.1 ± 7.80	67.3 ± 3.89
Phe	30.9 ± 3.14	32.2 ± 4.08	31.8 ± 2.94	32.5 ± 3.83	34.8 ± 2.21	33.3 ± 2.54	32.7 ± 2.65	33.4 ± 1.54
His	31.7 ± 4.04	33.2 ± 4.17	33.8 ± 4.68	33.1 ± 3.31	36.4 ± 1.15	33.9 ± 1.99	32.8 ± 3.22	31.8 ± 1.88
Lys	73.2 ± 9.21	74.7 ± 9.43	84.4 ± 7.44	80.9 ± 8.88	74.9 ± 4.33	75.4 ± 7.66	75.5 ± 11.64	79.9 ± 6.53
Arg	59.5 ± 7.41^{a}	62.2 ± 7.30^{ab}	62.9 ± 4.66^{ab}	63.3 ± 7.79^{ab}	68.0 ± 3.04^{b}	64.6 ± 4.8^{ab}	64.0 ± 4.99^{ab}	65.3 ± 3.43^{ab}

AA = Aberdeen Angus, BA = Blonde d'Aquitaine, Lim = Limousine, Char = Charolais, Gas = Gasconne cattle, MS = Meat Simmental, Sal = Salers, Gall = Galloway cattle

$^{a–d}$means within the same row with different superscripts significantly differ ($P \leq 0.05$)

Table 3. Mean values (in g/kg) of non-essential amino acids in the meat cattle breeds muscle tissue dry matter (n = 10)

Breed $\bar{x}$	AA	BA	Lim	Char	Gas	MS	Sal	Gall
Asp	69.3 ± 8.18^{a}	71.8 ± 8.15^{ab}	73.7 ± 5.19^{b}	75.0 ± 9.60^{ab}	75.2 ± 4.68^{b}	75.5 ± 5.22^{ab}	76.0 ± 5.86^{ab}	77.3 ± 5.06^{ab}
Ser	29.4 ± 3.69^{acd}	31.0 ± 3.64$^{b–d}$	31.1 ± 1.86$^{a–d}$	31.1 ± 3.81$^{a–d}$	34.9 ± 0.73^{b}	32.0 ± 2.17$^{a–d}$	31.4 ± 2.72$^{a–d}$	32.3 ± 1.88$^{a–d}$
Glu	103.4 ± 14.92^{a}	112.1 ± 17.14^{ab}	122.2 ± 9.56^{b}	116.6 ± 15.66^{ab}	127.8 ± 2.87^{b}	121.6 ± 9.54^{b}	116.9 ± 11.43^{b}	121.2 ± 8.37^{b}
Pro	38.8 ± 6.10^{ac}	39.9 ± 5.11$^{a–c}$	41.6 ± 2.76$^{a–c}$	42.0 ± 4.04$^{a–c}$	46.3 ± 1.82^{b}	43.0 ± 4.35$^{a–c}$	40.8 ± 2.93$^{a–c}$	44.4 ± 5.26$^{a–c}$
Gly	42.4 ± 4.87$^{a–e}$	44.5 ± 6.27$^{a–e}$	39.5 ± 3.98^{acde}	41.3 ± 5.47$^{a–e}$	50.4 ± 2.69^{b}	45.0 ± 4.00$^{a–e}$	41.8 ± 4.49$^{a–e}$	44.6 ± 4.42$^{a–e}$
Ala	46.0 ± 6.63^{a}	47.9 ± 5.85^{ab}	49.6 ± 3.37^{ab}	48.2 ± 5.55^{ab}	52.6 ± 1.07^{b}	49.5 ± 3.14^{ab}	48.0 ± 3.60^{ab}	49.6 ± 2.02
Tyr	32.6 ± 4.07	33.3 ± 4.32	30.5 ± 2.75	34.6 ± 4.04	35.1 ± 3.66	34.8 ± 3.24	32.4 ± 6.63	32.7 ± 2.69

AA = Aberdeen Angus, BA = Blonde d'Aquitaine, Lim = Limousine, Char = Charolais, Gas = Gasconne cattle, MS = Meat Simmental, Sal = Salers, Gall = Galloway cattle

$^{a–e}$means within the same row with different superscripts significantly differ ($P \leq 0.05$)

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In the monitored meat cattle breeds, the percentages of essential (Table 2) and non-essential (Table 3) amino acids in the dry matter of muscle tissue were determined. Out of the EAAs in the dry matter of muscle tissue, the highest percentage of all genotypes was found for Lys from 73.2 ± 9.21 (AA) to 84.4 ± 7.44 g/kg (Lim). The lowest percentage was found for Met from 18.2 ± 2.50 g/kg (AA) to 25.1 ± 1.29 g/kg (Gas). The Thr value was approximately (g/kg) 36, Val 41, Ile 38, Leu 66, Phe 33, His 33, and Arg 64. The sum of the EAAs ranged from 382.2 ± 46.32 (AA) to 433.1 ± 19.69 g/kg (Gas). Significant differences ($P \leq 0.05$) between the genotypes of meat cattle were found in the EAAs Val, Met, and Arg.

Out of the NEAAs (Table 3), the highest percentage in the dry matter of muscle tissue was found for Glu from 103.4 ± 14.92 (AA) to 127.8 ± 2.87 g/kg (Gas). The lowest values were found for Ser ranging from 29.4 ± 3.69 (AA) to 34.9 ± 0.73 g/kg (Gas). The other NEAAs showed values of approximately (g/kg) 74 for Asp, 42 for Pro, 44 for Gly, 49 for Ala, and 33 for Tyr. The sum of the NEAAs ranged from 361.8 ± 44.71 (AA) to 422.3 ± 10.25 g/kg (Gas). Significant differences ($P \leq 0.05$) between the genotypes of meat cattle were found for all NEAAs except for Tyr.

Out of the EAAs in all genotypes, the highest percentage in the protein of the dry matter of muscle tissue (Table 4) was found for Lys from 8.8% (Gas) to 10.4% (Lim). The lowest percentage was found for Met from 2.4 (AA, BA, Char) to 2.9% (Gas and Sal). The value of Thr was approximately 4.6, Val 5.1, Ile 4.8, Leu 8.2, Phe 4.1, His 4.2, and Arg 8.0%. Significant differences ($P \leq 0.05$) between the monitored breeds were found in all EAAs except for Val and Leu.

Out of the NEAAs (Table 5), the highest percentage of total protein in the dry matter of muscle tissue was found for Glu from 13.9 (AA) to 15.1% (Lim). Conversely, the lowest values were found for Ser (3.8 Lim to 4.1% Gas) and Tyr (3.8 Lim to 4.4% AA). The values of the other NEAAs were approximately 9.3 for Asp, 4.0 for Ser, 5.3 for Pro, 5.5 for Gly, and 6.1% for Ala. Significant differences ($P \leq 0.05$) were found between the monitored genotypes in all NEAAs except for Pro and Ala.

The mentioned values of EAAs and NEAAs are in agreement with, or close to the values stated by Subrt et al. (2002). Minor differences in the values can be affected by the different weights of

Table 4. Mean values of essential amino acids in the protein of the meat cattle breeds muscle tissue dry matter (%) ($n = 10$)

Breed $\bar{x}$	AA	BA	Lim	Char	Gas	MS	Sal	Gall
Thr	4.6 ± 0.11^{ab}	4.5 ± 0.12^{ab}	4.5 ± 0.11^{ab}	4.5 ± 0.14^{a}	4.6 ± 0.06^{ab}	4.5 ± 0.07	4.6 ± 0.09^{b}	4.6 ± 0.07
Val	5.1 ± 0.19	5.1 ± 0.17	5.2 ± 0.11	5.0 ± 0.09	5.2 ± 0.10	5.0 ± 0.15	4.8 ± 0.72	5.1 ± 0.03
Met	2.4 ± 0.12^{b}	2.4 ± 0.31^{b}	2.7 ± 0.12^{ab}	2.4 ± 0.18^{b}	2.9 ± 0.06^{a}	2.7 ± 0.23^{ab}	2.9 ± 0.35^{a}	2.6 ± 0.18^{ab}
Ile	4.8 ± 0.10^{ab}	4.8 ± 0.10^{ab}	4.9 ± 0.13^{b}	4.8 ± 0.13^{ab}	4.7 ± 0.03^{ab}	4.7 ± 0.11^{ab}	4.6 ± 0.40^{a}	4.7 ± 0.06^{ab}
Leu	8.2 ± 0.17	8.3 ± 0.17	8.5 ± 0.15	8.3 ± 0.26	8.2 ± 0.10	8.2 ± 0.24	8.2 ± 0.56	8.2 ± 0.18
Phe	4.2 ± 0.13^{b}	4.1 ± 0.11^{b}	3.9 ± 0.10^{a}	4.1 ± 0.09^{b}	4.1 ± 0.13^{ab}	4.1 ± 0.09^{b}	4.1 ± 0.15^{b}	4.1 ± 0.04^{b}
His	4.3 ± 0.17^{b}	4.3 ± 0.17^{b}	4.2 ± 0.37^{ab}	4.2 ± 0.16^{ab}	4.3 ± 0.02^{b}	4.2 ± 0.09^{ab}	4.2 ± 0.25^{ab}	3.9 ± 0.34^{a}
Lys	$9.8 \pm 0.33^{b-d}$	$9.6 \pm 0.53^{b-d}$	10.4 ± 0.33^{b}	10.2 ± 0.36^{bd}	8.8 ± 0.23^{acd}	$9.3 \pm 0.61^{a-d}$	$9.5 \pm 0.94^{b-d}$	$9.8 \pm 0.35^{b-d}$
Arg	8.0 ± 0.20^{ab}	8.0 ± 0.25^{ab}	7.8 ± 0.19^{a}	7.9 ± 0.28^{ab}	8.0 ± 0.11^{ab}	8.0 ± 0.16^{ab}	8.1 ± 0.38^{b}	8.0 ± 0.11^{ab}

AA = Aberdeen Angus, BA = Blonde d'Aquitaine, Lim = Limousine, Char = Charolais, Gas = Gasconne cattle, MS = Meat Simmental, Sal = Salers, Gall = Galloway cattle

$^{a-d}$means within the same row with different superscripts significantly differ ($P \leq 0.05$)

Table 5. Mean values of non-essential amino acids in the protein of the meat cattle breeds muscle tissue dry matter (%) (n = 10)

Breed $\bar{x}$	AA	BA	Lim	Char	Gas	MS	Sal	Gall
Asp	9.3 ± 0.22^{bc}	9.2 ± 0.31$^{a–c}$	9.1 ± 0.50$^{a–c}$	9.4 ± 0.24^{bc}	8.8 ± 0.44^{ac}	9.3 ± 0.29^{bc}	9.6 ± 0.29^{b}	9.4 ± 0.18^{bc}
Ser	4.0 ± 0.07^{b}	4.0 ± 0.07^{bc}	3.8 ± 0.09^{a}	3.9 ± 0.09^{b}	4.1 ± 0.07^{bc}	3.9 ± 0.06^{ab}	4.0 ± 0.09^{b}	4.0 ± 0.03^{b}
Glu	13.9 ± 0.98^{a}	14.4 ± 1.01^{ab}	15.1 ± 0.25^{b}	14.6 ± 0.80^{ab}	14.9 ± 0.25^{b}	15.0 ±0.59^{b}	14.8 ± 0.92^{ab}	14.8 ± 0.35^{ab}
Pro	5.2 ± 0.51	5.1 ± 0.39	5.2 ± 0.37	5.3 ± 0.39	5.4 ± 0.13	5.3 ± 0.40	5.2 ± 0.26	5.4 ± 0.41
Gly	5.7 ± 0.25^{bc}	5.7 ± 0.43^{bc}	4.9 ± 0.48^{a}	5.2 ± 0.59$^{a–c}$	5.9 ± 0.49^{bc}	5.6 ± 0.42$^{a–c}$	5.3 ± 0.52$^{a–c}$	5.5 ± 0.54$^{a–c}$
Ala	6.2 ± 0.36	6.2 ± 0.15	6.1 ± 0.18	6.0 ± 0.13	6.2 ± 0.30	6.1 ± 0.17	6.1 ± 0.20	6.1 ± 0.13
Tyr	4.4 ± 0.16^{b}	4.3 ± 0.32^{ab}	3.8 ± 0.10^{a}	4.3 ± 0.11^{ab}	4.1 ± 0.31^{ab}	4.3 ± 0.28^{ab}	4.1 ± 0.90^{ab}	4.0 ± 0.35^{ab}

AA = Aberdeen Angus, BA = Blonde d'Aquitaine, Lim = Limousine, Char = Charolais, Gas = Gasconne cattle, MS = Meat Simmental, Sal = Salers, Gall = Galloway cattle

$^{a–c}$means within the same row with different superscripts significantly differ ($P \leq 0.05$)

Table 6. Sum of the mean values of non-essential and essential amino acids in the meat cattle breeds muscle tissue dry matter, along with their mutual proportion in g/kg and percentages (n = 10)

Breed $\bar{x}$	AA	BA	Lim	Char	Gas	MS	Sal	Gall
ΣNEAAs (g/kg)	361.8 ± 44.71^{a}	380.4 ± 45.91^{ab}	388.1 ± 24.04^{ab}	388.8 ± 44.26^{ab}	422.3 ± 10.33^{b}	401.3 ± 25.87^{ab}	387.3 ± 28.06	402.1 ± 21.80^{ab}
ΣEAAs (g/kg)	382.2 ± 46.32	397.3 ± 45.52	421.5 ± 35.06	408.5 ± 46.79	433.1 ± 19.69	411.3 ±29.47	404.4 ± 41.35	416.4 ± 22.40
ΣAAs (g/kg)	744.0 ± 89.45^{a}	777.8 ± 90.33^{ab}	809.6 ± 57.61^{ab}	797.3 ± 90.83^{ab}	855.4 ± 29.34^{b}	812.6 ± 54.74^{ab}	791.6 ± 65.32^{ab}	818.5 ± 43.50^{ab}
ΣNEAAs (%)	48.6 ± 1.13^{ab}	48.9 ± 0.90^{ab}	48.0 ± 0.95^{a}	48.8 ± 0.41^{ab}	49.4 ± 0.65^{b}	49.4 ± 0.55^{b}	49.0 ± 1.71^{ab}	49.1 ± 0.49^{ab}
ΣEAAs (%)	51.4 ± 1.13^{ab}	51.1 ± 0.90^{ab}	52.0 ± 0.95^{ab}	51.2 ± 0.41^{a}	50.6 ± 0.65^{b}	50.6 ± 0.55^{b}	51.0 ± 1.71^{ab}	50.9 ± 0.49^{ab}

EAAs = essential amino acids, NEAAs = non-essential amino acids, AAs = amino acids, AA = Aberdeen Angus, BA = Blonde d'Aquitaine, Lim = Limousine, Char = Charolais, Gas = Gasconne cattle, MS = Meat Simmental, Sal = Salers, Gall = Galloway cattle

^{a,b}data within the same row with different superscripts significantly differ ($P \leq 0.05$)

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the bulls or the dry matter of muscle tissue, and an explanation can also be found in the different representations of the monitored breeds. A significant role is played by the sex of the monitored animals (Hollo et al. 2001; Koutsidis et al. 2008). Bulls that have a higher growth intensity, which is given by the production of androgens, show an increased anabolic activity, stimulating protein synthesis. This knowledge was used (or misused) in the past in the hormonal stimulation of growth in bulls during fattening. The opinion of Hollo et al. (2001) is different; they stated that the quantity of EAAs was significantly larger in females than in males.

We consider the apparently higher percentage of Glu (13.9–15.1%) to be significant, which is in full agreement with the data from Subrt et al. (2002) and Barabas (1987), who present values 14.8–16.8 and 15.5%, respectively. The Glu content has a significant effect on the taste of meat. In other AAs, the effect on aroma prevails, along with the effect on taste intensification, so-called umami (Fujimura and Kadowaki 2006). Apart from the four basic human tastes (sweet, bitter, salty, and sour), umami is the fifth major taste. The specific gustatory receptor for umami – mGluR4 – was discovered in 2000 (Chaudhari et al. 2000; Lindemann 2001; Lindemann et al. 2002), and it perceives glutamic acid or its glutamate salts contained in food.

Free amino acid dipeptides occur at low concentrations in muscle. Muscle aminopeptidases contribute to the generation of free amino acids *post mortem*. The concentration of each amino acid is important for its contribution to taste (Kato et al. 1989). A negative relation was observed (Szucs et al. 1985) between the arginine and histidine contents of beef and its tastiness. According to Feidt et al. (1996), the release of free amino acids in bovine meat is strongly muscle type dependent.

The total quantity of essential and non-essential amino acids in the dry matter of muscle tissue in meat bull breeds (Table 6) ranged from (g/kg) 744.0 (AA) to 855.4 (Gas) ($P < 0.05$), in EAAs from 382.2 (AA) to 433.1 (Gas), and in NEAAs from 361.8 (AA) to 422.3 (Gas) ($P < 0.05$). The mutual EAA/NEAA ratio was the lowest in Lim (0.92) and the highest in Gas and MS (0.98) ($P < 0.05$). The percentage of EAAs was the lowest in Gas and MS (50.61%) and the highest in Lim (52.03%); in NEAAs, the values ranged from 47.97% (Lim) to 49.39% (MS) ($P < 0.05$).

The study results obtained in weight and age balanced groups of eight meat bull breeds bred in the same geographical conditions in the area of Southern Bohemia, with the extensive type of nutrition, proved a number of significant differences between the values of EAAs and NEAAs in the *musculus longissimus*. This agrees with the knowledge from Subrt et al. (2002), who also found significant differences in a number of EAAs and NEAAs. Hollo et al. (2007) state that an extensive diet with grass/grass silage and concentrate with linseed supplements caused changes in the proportion of some amino acids compared to that of intensive groups. The enhancement of the Phe, Val, Pro, and ammonia concentrations and the decrease of Ile, Leu, Thr, Cys, Gly, and Ser were observed. Breed differences were detected only for the His concentration of the *musculus longissimus*. The meat cattle that we monitored were bred solely in the extensive method and the differences between individual AAs in connection with intensive diet, as stated by Hollo et al. (2007), could not be found. However, we also found significant differences between the monitored breeds in the *musculus longissimus*.

Jeong et al. (2012) focused on the comparison of meat quality traits, free amino acids, and fatty acids in *longissimus lumborum* muscles from Hanwoo, Holstein, and Angus steers, fattened in Korea. The results of this study have shown that there were no dramatic differences between beef from the three breeds that were fattened for 6 months under equal conditions.

A possible effect of feeding high or low indispensable amino acids can influence the amino acid structure and simultaneously the growth performance of bulls (Kluth et al. 2000). Contrary to other species, there is very little known about the influence of diet on the amino acid content in beef. However, investigations of the factors controlling the amino acid content of muscles are necessary in order to improve the quality and safety of meat.

CONCLUSION

The results of the study performed on groups of eight modern beef cattle breeds of equal weight and age that were extensively fed and bred in the same geographical conditions demonstrated a number of differences between the values of EAAs and NEAAs in the *musculus longissimus*. Regarding EAAs in the muscle dry matter, lysine had the highest proportion among all investigated genotypes of bulls; the lowest proportion was found for methionine. Regarding NEAAs, glutamic acid had the highest

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proportion; the lowest values were found for serine. Apart from its effect on the biological value of meat, the representation of individual amino acids is important to enhance its taste or smell.

REFERENCES

AOAC (2006): Official Methods of Analysis of AOAC International. 18th Ed. Association of Official Analytical Chemists, Gaithersburg, USA.

Applegate T.J., Angel R. (2008): Protein and amino acid requirements for poultry. Purdue University Extension Publication AS-581-W. Available from http://www.puyallup.wsu.edu/dairy/nutrient-management/default.asp (accessed Sep 1, 2016).

Barabas J. (1987): Biological value of some proteins of animal provenience. Agriculture, 33, 686–691. (in Czech)

Baker D.H. (1997): Ideal amino acid profiles for swine and poultry and their application in feed formulation. BioKyowa Technical Review, 9, 1–24.

Chaudhari N., Landin A.M., Roper S.D. (2000): A novel metabotropic glutamate receptor functions as a taste receptor. Nature Neuroscience, 3, 113–119.

Feidt C., Petit A., Bruas-Reignier F., Brun-Bellut J. (1996): Release of free amino-acids during ageing in bovine meat. Meat Science, 44, 19–25.

Fujimura S., Kadowaki M. (2006): Improvement of meat taste by dietary components. Bulletin of the Faculty of Agriculture, Niigata University, 58, 151–153.

Hanzelkova S., Simeonovova J., Hampel D., Dufek A., Subrt J. (2011): The effect of breed, sex and aging time on tenderness of beef meat. Acta Veterinaria Brno, 80, 191–196.

Hollo G., Csapo J., Szucs E., Tozser J., Repa I., Hollo I. (2001): Influence of breed, slaughter weight and gender on chemical composition of beef. Part 1. Amino acid profile and biological value of proteins. Asian-Australasian Journal of Animal Sciences, 14, 1555–1559.

Hollo G., Nuernberg K., Hollo I., Csapo J. Seregi J., Repa I., Ender K. (2007): Effect of feeding on the composition of longissmus muscle of Hungarian Grey and Holstein Friesian bulls. III. Amino acid composition and mineral content. Archiv fur Tierzucht, 50, 575–586.

Ito R.H., Valero M.V., do Prado R.M., Rivaroli D.C., Perotto D., do Prado I.N. (2012): Meat quality from four genetic groups of bulls slaughtered at 14 months old. Acta Scientiarum, Animal Sciences, 34, 425–432.

Jeong D., Oh M.R., Seong P.N., Cho S., Kang G.H., Kim J.H., Jeong S.G., Lee J.S, Park B.Y. (2012): Comparison of meat quality traits, free amino acid and fatty acid on longissimus lumborum muscles from Hanwoo, Holstein and Angus steers, fattened in Korea. Korean Journal for Food Science of Animal Resources, 32, 591–597.

Kato H., Rhue M.R., Nishimura T. (1989): Role of free amino acids and peptides in food taste. In: Teranishi R., Buttery R.G., Shahidi F. (eds): Flavor Chemistry: Trends and Developments. ACS Symposium Series, 388, 158–174.

Kluth H., Gabel M., Voigt J., Schonhusen U. (2000): The efficiency of utilization of intestinal digestible indispensable amino acids in growing bulls. Archiv fur Tierzucht, 43, 621–631. (in German)

Koutsidis G., Elmore J.S., Oruna-Concha M.J., Campo M.M., Wood J.D., Mottram D.S. (2008): Water-soluble precursors of beef flavour, I. Effect of diet and breed. Meat Science, 79, 124–130.

Lindemann B., Ogiwara Y., Ninomiya Y. (2002): The discovery of umami. Oxford Journals, Chemical Senses, 27, 843–844.

Lindemann B. (2001): Receptors and transduction in taste. Nature, 413, 219–225.

Salehifar E., Shivazad M., Foroudi F., Chamani M., Kashani R.B. (2012): Reevaluation of digestible amino acid requirements of male and female broilers based on different ideal amino acids rations in starter period. Livestock Science, 147, 154–158.

Saunders A.J., Wessels J.P.H., Gous R.M. (1977): Carcass amino acid composition and utilization of dietary amino acids by chickens. South African Journal of Animal Science, 7, 111–115.

Stilborn H.L., Moran E.T., Gous R.M., Harrison M.D. (1997): Effect of age on feather amino acid contents from two broiler strain crosses and sexes. Journal of Applied Poultry Research, 6, 205–209.

Stilborn H.L., Moran E.T., Gous R.M., Harrison M.D. (2010): Influence of age on carcass (feather-free) amino acid for two broiler strain crosses and sexes. Journal of Applied Poultry Research, 19, 13–23.

Strakova E., Suchy P., Navratil P., Karel T., Herzig I. (2015): Comparison of the content of crude protein and amino acids in the whole bodies of cocks and hens of Ross 308 and Cobb 500 hybrids at the end of fattening. Czech Journal of Animal Science, 60, 67–74.

Subrt J., Kracmar S., Divis V. (2002): The profile of amino acids in intramuscular protein of bulls of milked and beef commercial types. Czech Journal of Animal Science, 47, 21–29.

Szucs E., Votisky L., Csiba A., Acs I. (1985): Data on the amino acid composition and the biological value of the meat of young bulls. Húsipar, 24, 156–159. (in Hungarian)

Tumova E., Chodova D., Svobodova J., Uhlirova L., Volek Z. (2015): Carcass composition and meat quality of Czech genetic resources of nutrias (Myocastor coypus). Czech Journal of Animal Science, 60, 479–486.

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