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Effect of cattle breed on muscle protein quality

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Abstract: The aim of the study was to compare the muscle protein quality in the *m. longissimus*, *pars thoracis* of bulls of the Aberdeen Angus (AA) and Czech Fleckvieh (CF) breeds reared under identical conditions within an extensive pasture-based system. The CF breed exhibited a higher crude protein content (887 ± 87.4 g/kg of dry matter) compared to AA (812 ± 59.3 g/kg of dry matter); $P \leq 0.05$. A higher content of non-essential amino acids was recorded in CF (390 ± 37.9 g/kg of dry matter) compared to AA (364 ± 44.5 g/kg of dry matter); $P \leq 0.05$, as well as higher contents of essential amino acids (CF 406 ± 38.9 g/kg of dry matter, AA 382 ± 41.0 g/kg of dry matter; $P \leq 0.05$) and total analysed amino acids (CF 796 ± 74.8 g/kg of dry matter, AA 746 ± 82.7 g/kg of dry matter; $P \leq 0.05$). Breed-related differences were observed in the content of most analysed amino acids ($P \leq 0.05$), except for tyrosine and phenylalanine, for which no effect of breed was found ($P > 0.05$). Lysine showed the highest content among essential amino acids (AA 73.4 ± 8.23 g/kg of dry matter, CF 76.6 ± 8.87 g/kg of dry matter; $P \leq 0.05$), while glutamic acid was dominant among non-essential amino acids (AA 109 ± 14.4 g/kg of dry matter, CF 119 ± 12.5 g/kg of dry matter; $P \leq 0.05$). The ratio of essential to non-essential amino acids (EAA/NEAA) did not differ between breeds (AA 1.05 ± 0.08, CF 1.04 ± 0.05; $P > 0.05$). The results indicate that cattle breed affects the content of crude protein and the content of most analysed amino acids in the muscle tissue of AA and CF breeds; however, the EAA/NEAA ratio remains unaffected by breed.

Keywords: beef; genotype; nutrients; nutritional quality; pasture

Beef is a rich source of protein, and its protein content is relatively stable (Fruet et al. 2018; Najar-Villarreal et al. 2019; Siphambili et al. 2020; Gunduz and Cayiroglu 2024; Mujic et al. 2025). It has high contains of anserine, carnosine, and glutathione, which exhibit antioxidant activity (Wu et al. 2016). Beef is also characterised by a favourable amino acid profile. The consumption of beef provides essential amino acids that cannot be synthesised by the human body (Samicho et al. 2013). Glutamic acid is the most abundant amino acid, followed by lysine (Wu et al. 2016). The amino acid content influences the sensory characteristics of beef, with meat flavour being positively affected by glutamic acid, glycine, and alanine (Hoa et al. 2023; Tsitsos et al. 2024).

Ruminants obtain a high proportion of essential amino acids through microbial fermentation (Koutsidis et al. 2008; Zahradkova 2009). In the rumen, 40–90% of dietary protein is degraded and transformed by microbial activity into microbial protein. Therefore, an optimal diet for cattle should contain rumen degradable protein and rumen undegradable protein. Rumen degradable protein serves as a source of nitrogen for rumen microorganisms, thereby supporting the synthesis of microbial protein, which is digested into amino acids in the small intestine. Rumen undegradable

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protein passes intact to the small intestine where it contributes to fulfilling the animal's nutritional requirements that cannot be satisfied by microbial protein alone (Zahradkova 2009).

Cattle breed is one of the main factors affecting the quality and quantity of muscle tissue. Beef cattle breeds exhibit a higher protein content in muscle tissue compared to dairy and dual-purpose breeds, as their genetic potential is oriented towards meat production (Solarczyk et al. 2020; Kostusiak et al. 2023; Wisniewski et al. 2024). Late-maturing breeds, such as Blonde d'Aquitaine, have a higher proportion of muscle tissue than early-maturing breeds, such as Aberdeen Angus, in which fat deposition occurs earlier (Solarczyk et al. 2020). Intermediate-maturing breeds, such as Czech Fleckvieh, deposit fat earlier than late-maturing breeds and later than early-maturing breeds (Strapak et al. 2013).

Grazing represents the most natural feeding system for cattle, as the ruminant digestive tract is adapted to forage utilisation. Allowing cattle to graze is essential for meeting their nutritional and behavioural needs, contributing to their health and welfare, as well as to the production of high-quality animal products (Davis et al. 2022; Rivero and Lee 2022). When evaluating the effect of grazing on muscle protein content in beef, positive effects on total muscle protein (Hwang and Joo 2017) and negligible effects (Fruet et al. 2018; Najar-Villarreal et al. 2019; Siphambili et al. 2020) have been reported.

The nutritional quality of forage varies throughout the year (Kvapilik et al. 2006; Gillespie and Flanders 2010), with crude protein content in pasture being highest in spring and lowest in autumn. The quality of grazed forage is influenced by the botanical composition of the pasture, for example, legumes are characterised by a high protein content (Gillespie and Flanders 2010). The variability in pasture forage quality is also affected by its management (Kvapilik et al. 2006; Zahradkova 2009), the grazing system applied (Kvapilik et al. 2006; Zahradkova 2009; Augustine et al. 2020; Augustine et al. 2023), and the grazing behaviour of animals on pasture (Neave et al. 2022). Muscle type also affects the quality of muscle protein (Samicho et al. 2013; Fortova et al. 2018). It was observed that muscle type influenced protein content in the Czech Fleckvieh breed, with the *m. longissimus lumborum* containing the highest amount (Fortova et al. 2018). Differences in amino acid composition were also observed among individual muscles of Droughtmaster cattle. Glutamic acid was the most abundant amino acid across several analysed body parts, although its content varied between individual cuts, and the flank cut exhibited the highest leucine content (Samicho et al. 2013).

The aim of the study was to verify whether differences in muscle protein quality in the *m. longissimus*, *pars thoracis* could be demonstrated between two cattle breeds – the dual-purpose breed Czech Fleckvieh and the beef breed Aberdeen Angus – reared under identical conditions within an extensive pasture-based system, as both breeds were kept at the same pasture location and under the same feeding management.

MATERIAL AND METHODS

Cattle breed characteristics. The cattle breeds included in the study were selected because the Czech Fleckvieh (CF), represented the only dual-purpose breed present in the study area and, together with the beef breed Aberdeen Angus (AA), formed the largest group from which up to 65 muscle samples could be obtained. The Czech Fleckvieh, a dual-purpose breed, is characterised by high adaptability, enabling its efficient use for both combined production and specialised dairy or beef production. The Aberdeen Angus, a beef breed, is widely distributed and bred worldwide, and its meat is characterised by high tenderness.

Breeding conditions and pasture management. The animals were raised under an extensive pasture-based system. The grazing area of the studied cattle breeds was located at an altitude of 828 m in the Prachatice District of the South Bohemia Region, Czech Republic. The pasture area was secured using both solid and electric fencing. Drinking water was provided through tanks. Protection against unfavourable weather conditions was ensured by natural shelter. Conserved forage was offered when necessary in the form of bale feed. Salt and mineral licks were available ad libitum. The stocking density was approximately one animal per 2 ha. Slaughter took place over a two-year period according to slaughterhouse capacity, while the age of the bulls was maintained between 16 and 18 months. Free grazing was the preferred system, based on unrestricted animal movement across the pasture area, with minimal human intervention. The ration of the cattle was primarily dependent

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on pasture intake. The cattle grazed during both summer and winter seasons. During the main grazing period, from March to November, pasture constituted the primary component of the cattle's ration. The botanical composition of the pasture included grasses, with a predominance of red fescue (*Festuca rubra*), meadow fescue (*Festuca pratensis*), smooth meadow-grass (*Poa pratensis*), and legumes, mainly white clover (*Trifolii albi*). During the grazing season, the contents of crude protein and fat in the pasture gradually decreased from May to July, with average values increasing again in August. From May to July, average values of crude fibre and fibre fractions gradually increased, except for acid-detergent lignin, followed by a decrease in August. During the winter period, the ration consisted of haylage, hay, and straw. Table 1 shows the nutrient composition of the pasture.

Analytical methods. Grazing forage was collected on four occasions throughout the grazing season, with samples taken from 10 locations each time (n = 10), each representing an area of 1 m^2. The chemical analyses focused on the determination of dry matter (g/kg), measured by drying the samples at 105 °C under prescribed conditions, and on crude protein content (g/kg), calculated by multiplying the nitrogen content, determined using the Kjeldahl method, by a factor of 6.25. Nitrogen was analysed using a Buchi analyser (Centec automation, company s.r.o., Prague, Czech Republic). Fat content (g/kg) was determined by extraction with an Ankom XT10 Fat Analyser (O.K. SERVIS BioPro, Prague, Czech Republic). Crude fibre (g/kg) and fibre fractions – including acid detergent fibre (ADF), neutral detergent fibre (NDF), and acid detergent lignin (ADL) – were analysed using an Ankom 220 Fiber Analyser (O.K. SERVIS BioPro, Prague, Czech Republic). Ash content (g/kg) was measured by weighing following incineration at 550 °C under prescribed conditions. Selected macro-elements (g/kg) were determined by atomic absorption spectrometry using an Agilent Technologies Series 240 AA instrument (Altium International s.r.o., Prague, Czech Republic). Nitrogen-free extract (NFE) was calculated as: NFE (g/kg) = dry matter – (crude protein + fat + crude fibre + ash). Organic matter (OM) was expressed (g/kg) as the difference between dry matter and ash. Gross energy (MJ/kg) was determined calorimetrically using an AC 500 Calorimeter (LECO Instrumente, s.r.o., Plzeň, Czech Republic).

Table 1. Average nutrient content (g/kg), including gross energy (MJ/kg), on a fresh matter basis in the pasture during the growing season (n = 10)

Nutrients	May	June	July	August
	x ± SD			
Dry matter	185 ± 15.4	196 ± 22.2	220 ± 16.0	190 ± 15.9
Crude protein	43.7 ± 4.32	38.9 ± 5.26	36.6 ± 5.96	47.7 ± 10.2
Fat	7.84 ± 1.00	6.09 ± 0.66	5.22 ± 0.51	5.81 ± 1.01
Crude fibre	38.9 ± 3.56	45.5 ± 7.02	48.1 ± 5.11	35.7 ± 3.02
ADF	52.1 ± 2.18	59.2 ± 6.88	65.6 ± 7.34	52.8 ± 5.48
NDF	79.5 ± 9.04	96.2 ± 16.5	104 ± 14.6	78.2 ± 7.46
ADL	13.8 ± 2.84	9.92 ± 1.18	13.3 ± 1.35	12.2 ± 2.38
NFE	74.4 ± 10.3	86.3 ± 13.7	110 ± 12.6	81.7 ± 7.50
OM	165 ± 15.4	177 ± 22.5	200 ± 15.3	180 ± 44.2
GE	3.42 ± 0.34	3.62 ± 0.42	4.00 ± 0.30	2.49 ± 1.38
Ash	20.1 ± 1.32	19.4 ± 1.48	19.9 ± 1.33	19.3 ± 1.71
Ca	0.68 ± 0.15	1.00 ± 0.16	1.68 ± 0.38	1.41 ± 0.18
P	0.86 ± 0.12	0.76 ± 0.05	0.82 ± 0.12	0.77 ± 0.15
Mg	0.53 ± 0.12	0.73 ± 0.08	0.62 ± 0.12	0.60 ± 0.10
Na	0.10 ± 0.00	0.10 ± 0.00	0.13 ± 0.05	0.04 ± 0.06
K	4.71 ± 0.82	5.45 ± 0.44	4.07 ± 0.98	4.52 ± 0.15

Mean (x) ± standard deviation (SD)

ADF = acid detergent fibre; ADL = acid detergent lignin; GE = gross energy; NDF = neutral detergent fibre; NFE = nitrogen-free extract; OM = organic matter

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Samples were collected from the "top sirloin" section at the Volary slaughterhouse, ZEFA, from 65 Aberdeen Angus and 65 Czech Fleckvieh bulls. The bulls were slaughtered at the age of 16–18 months. From each animal, 500 g sample was taken from the *m. longissimus*, *pars thoracis*, which was located on the left side of the carcass between the 6th and 8th thoracic vertebrae. The samples were cooled and frozen before the chemical analyses. The chemical analyses focused on the determination of dry matter (g/kg), measured by drying the samples at 105 °C under prescribed conditions using the gravimetric method. Crude protein content was calculated as nitrogen determined by the Kjeldahl method multiplied by the factor 6.25. The nitrogen was analysed on the Buchi analyser (Centec automation, company s.r.o., Prague, Czech Republic). Amino acid content was determined after acid hydrolysis of the samples using an automatic amino acid analyser AAA 400 (INGOS a.s., Prague, Czech Republic) based on the colour reaction of amino acids with ninhydrin. From the spectrum of analysed amino acids, attention was focused on aspartic acid (Asp), threonine (Thre), 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).

Statistical analysis. Among the basic statistical characteristics, attention was focused on the number of samples (n), the mean (x), and the standard deviation (SD). Statistical evaluation included testing the normality of the data distribution using the Shapiro–Wilk test in the software Unistat v6.5 (Unistat Ltd., London, UK) where the data fulfilled the condition of normal distribution ($P > 0.05$). Homogeneity of variances for the monitored indicators was assessed using the F-test, followed by the calculation of the Student's t-test. Differences between mean values were evaluated at the significance level of $P \leq 0.05$ and were considered statistically significant (*).

RESULTS AND DISCUSSION

Amount of muscle protein. Table 2 shows that a difference in muscle crude protein content was observed between the selected cattle breeds, with the Czech Fleckvieh breed exhibiting higher content. The crude protein content in the muscle tissue was 812 g/kg of dry matter for the Aberdeen Angus breed and 887 g/kg of dry matter for the Czech Fleckvieh breed ($P \leq 0.05$). These results indicate that the breed may affect muscle crude protein content. The observed differences can be explained by the different production types of the breeds and their varying maturation periods, which are determined by their genotype. CF is a dual-purpose breed that reaches the body development stage associated with intensive fat deposition more slowly than the AA breed, which reaches this stage faster. This genetically determined trait of the AA breed leads to increased intramuscular fat content, which is characteristic of its muscle tissue (Bures and Barton 2018; Papanikolopoulou et al. 2025). Solarczyk et al. (2020), Chen et al. (2022), Ge et al. (2023), Kostusiak et al. (2023), Wisniewski et al. (2024) and Papanikolopoulou et al. (2025) reported that breed can affect muscle protein content. The *m. semimembranosus* of the beef breeds Limousine, Hereford, and Charolais exhibited higher protein content than the same muscle tissue from the dairy breed Holstein (Kostusiak et al. 2023). Likewise, Solarczyk et al. (2020) reported that the *m. semimembranosus* of Limousine exhibited higher protein content than that of Holstein. The *m. longissimus thoracis*, *m. infraspinatus*, and *m. longissimus lumborum* of Limousine were characterised by higher protein content than the same muscle tissues from the dual-purpose breed Polish Red (Wisniewski et al. 2024). Local Chinese cattle breeds exhibited higher protein content in the *m. longissimus dorsi* than intensively bred cattle breeds selected specifically for production traits (Ge et al. 2023). The *m. longissimus dorsi* of Aberdeen Angus bulls contained the lowest proportion of protein when compared to the same muscle tissue of Limousine and Holstein bulls (Papanikolopoulou et al. 2025). In contrast, no difference in protein content was observed in the *m. longissimus lumborum* of Aberdeen Angus and Czech Fleckvieh bulls, which were fed the same feeding ratio and slaughtered at around 17 months of age (Bures and Barton 2018).

Amino acid profile. Table 2 presents the differences observed in the content of non-essential amino acids (NEAA), the content of essential amino acids (EAA), and the total content of analysed amino acids (AAs) in the muscle tissue of the selected cattle breeds, with higher values recorded in the CF breed for all evaluated traits. The content of NEAA was 364 g/kg of dry matter in AA and 390 g/kg of dry matter in CF ($P \leq 0.05$). The content of EAA was

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Table 2. Amino acid profile (g/kg of dry matter) in the muscle tissue of bulls of the Aberdeen Angus (n = 65) and Czech Fleckvieh (n = 65) breeds

Nutrients	Aberdeen Angus x ± SD	Czech Fleckvieh x ± SD	P-value
Crude protein	812 ± 59.3	887 ± 87.4	*
AAs	746 ± 82.7	796 ± 74.8	*
EAA	382 ± 41.0	406 ± 38.9	*
Threonine	33.7 ± 4.12	36.0 ± 3.64	*
Valine	37.4 ± 4.36	40.1 ± 4.20	*
Methionine	19.1 ± 2.67	21.5 ± 2.57	*
Isoleucine	35.4 ± 3.95	37.9 ± 3.71	*
Leucine	61.4 ± 6.47	65.5 ± 6.93	*
Phenylalanine	30.7 ± 3.32	31.6 ± 3.76	ns
Histidine	31.9 ± 4.65	34.3 ± 4.63	*
Lysine	73.4 ± 8.23	76.6 ± 8.87	*
Arginine	59.3 ± 6.56	62.4 ± 7.55	*
NEAA	364 ± 44.5	390 ± 37.9	*
Aspartic acid	70.1 ± 8.06	74.5 ± 7.50	*
Serine	29.2 ± 3.58	31.8 ± 6.20	*
Glutamic acid	109 ± 14.4	119 ± 12.5	*
Proline	38.0 ± 8.16	41.4 ± 5.19	*
Glycine	40.7 ± 6.32	43.2 ± 5.73	*
Alanine	45.5 ± 5.86	48.6 ± 5.17	*
Tyrosine	31.4 ± 4.22	31.0 ± 4.01	ns
EAA/NEAA	1.05 ± 0.08	1.04 ± 0.05	ns

Mean (x) ± standard deviation (SD); $^*P \leq 0.05$

AAs = amino acids; EAA = essential amino acids; NEAA = non-essential amino acids; ns = not significant

382 g/kg of dry matter in AA and 406 g/kg of dry matter in CF ($P \leq 0.05$). The total content of AAs was 746 g/kg of dry matter in AA and 796 g/kg of dry matter in CF ($P \leq 0.05$). Breed-related differences were observed for all analysed amino acids ($P \leq 0.05$), except for Tyr and Phe ($P > 0.05$). Glu was the dominant amino acid within the NEAA group (AA 109 g/kg of dry matter, CF 119 g/kg of dry matter; $P \leq 0.05$) and Lys was the dominant amino acid within the EAA group (AA 73.4 g/kg of dry matter, CF 76.6 g/kg of dry matter; $P \leq 0.05$). These results indicate that breed may affect the content of analysed amino acids and influence the nutritional quality of muscle protein. Koutsidis et al. (2008), Vopalensky et al. (2017), Chen et al. (2022) and Ge et al. (2023) reported that breed can affect content of amino acids in muscle tissue. Differences in the content of individual amino acids were observed in the *m. longissimus lumborum* of Aberdeen Angus and Holstein where the muscle tissue of Aberdeen Angus contained a higher content of Arg, while the muscle tissue of Holstein showed a higher content of Gly (Koutsidis et al. 2008). In the *m. longissimus thoracis* of Aberdeen Angus, higher contents of Asn, Ala, Val, Met, Leu, and Nva (norvaline) and lower contents of Gly, Cys, and Phe were found compared to Xiangxi Yellow cattle (Chen et al. 2022). Vopalensky et al. (2017) reported that breed affected the content of Lys and Glu in the *m. longissimus thoracis*. Lys was the most abundant essential amino acid across different muscles of various cattle breeds (Samicho et al. 2013; Vopalensky et al. 2017; Ge et al. 2023; Merayo et al. 2023; Michalchenko et al. 2024), and Glu was the predominant amino acid within the non-essential amino acids in different muscles of various cattle breeds (Samicho et al. 2013; Vopalensky et al. 2017; Ge et al. 2023; Merayo et al. 2023). In contrast to our findings, no effect of breed on the content of Glu and Lys was observed in the *m. longissimus lumborum* and *m. longissimus thoracis* when comparing Aberdeen Angus with Holstein (Koutsidis et al. 2008) or with

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Xiangxi Yellow cattle (Chen et al. 2022). Breed can also affect total content of amino acids in muscle tissue (Vopalensky et al. 2017; Chen et al. 2022). Lower total content of amino acids was observed in Aberdeen Angus compared to Gasconne in the *m. longissimus thoracis* (Vopalensky et al. 2017). Higher total content of amino acids in the *m. longissimus thoracis* was reported in Aberdeen Angus compared to Xiangxi Yellow cattle (Chen et al. 2022). No effect of breed on the total content of amino acids was found when comparing the *m. longissimus lumborum* of Aberdeen Angus and Holstein cattle (Koutsidis et al. 2008). The dominant effect of breed on the amino acid profile of the *m. longissimus*, *pars thoracis* is indicated by the results obtained in the present study, in agreement with Vopalensky et al. (2017). In both studies, the same pasture location and the same feeding management were applied to the Aberdeen Angus breed. The only difference was the number of evaluated samples. The results of both studies were highly comparable, suggesting that breed is likely the main factor exerting a major influence on the amino acid profile of the *m. longissimus*, *pars thoracis*.

Table 2 also indicates that no difference was found in the EAA/NEAA ratio in the muscle tissue of both breeds. In Aberdeen Angus, a value of 1.05 was recorded for this parameter, while in Czech Fleckvieh the value was 1.04 ($P > 0.05$). This result reflects a balanced representation of amino acids in muscle protein and indicates that breed does not affect this trait. The ratio of essential to non-essential amino acids in the *m. longissimus thoracis* of Aberdeen Angus, Blonde d'Aquitaine, Limousine, Charolais, Gasconne, Meat Simmental, Salers, and Galloway was reported within a similar range (Vopalensky et al. 2017). In contrast, a lower ratio of essential to non-essential amino acids in the *m. longissimus thoracis* was observed in Charolais × Aberdeen Angus crossbreds (Merayo et al. 2023).

CONCLUSION

Cattle breed affected the crude protein content and the content of most amino acids in the *m. longissimus*, *pars thoracis* of bulls reared under identical conditions within an extensive pasture-based system. The Czech Fleckvieh breed exhibited a higher crude protein content as well as higher contents of essential, non-essential, and total analysed amino acids compared to the Aberdeen Angus breed. These differences may be attributed to differences in production type and intramuscular fat deposition. The EAA/NEAA ratio was not affected by breed, and its values indicate a high nutritional quality of muscle protein in both breeds. Overall, it can be concluded that cattle breed may influence the quality and quantity of muscle protein.

Conflict of interest

The authors declare no conflict of interest.

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