Evaluation of the technological quality and colour of the meat of Czech Fleckvieh bulls

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Abstract

The aim of this study was to evaluate the technological quality and colour of the meat of Czech Fleckvieh bulls. A total of 136 bulls were included in the experiment. Selected indicators of technological quality (water-holding capacity, pH value, area of *Musculus longissimus thoracis* (MLT) and muscle fibre diameter) and meat colour characteristics were evaluated according to age at slaughter, carcass weight and average daily gain. The area of MLT, muscle fibre diameter, pigment content and redness increased significantly ($p < 0.01$) depending on age at slaughter, carcass weight and average daily gain. The pH_{48} decreased significantly ($p < 0.01$) depending on age at slaughter and carcass weight. Water-holding capacity, lightness L* and yellowness b* were not influenced by the given factors.

Beef, carcass, CIELab system, muscle fibre diameter, water-holding capacity

Introduction

The cattle rearing is an integral part of Czech agriculture. The dominant position held by cattle lies in the production of milk, though beef production is certainly not insignificant. The Czech Fleckvieh is one of the most widespread cattle breeds reared in the Czech Republic. Today's consumer is becoming increasingly demanding when it comes to the quality of beef meat. Beef is considered food of extremely high quality with a high protein content. Bartoň et al. (2007) studied the effect of various types of silage in rations on the quality of Czech Fleckvieh bull carcasses. Filipčík et al. (2015) give technological parameters for beef sirloin from Czech Fleckvieh bulls (water-holding capacity 78.64%, area of MLT 86.73 cm^2, pH_{48} 5.63 and muscle fibre diameter 35.61 μm) in their work.

The aim of this work was to evaluate the effect of selected factors on the technological quality and colour of meat.

Materials and Methods

A total of 136 bulls of the Czech Fleckvieh breed were selected for the experiment. The bulls were then divided into two age categories according to age at slaughter. Category 1 was comprised of bulls aged between 520 and 540 days (n = 95), while category 2 was made up of bulls with a longer fattening period (640 to 760 days, n = 41). The carcasses were also divided into the three weight categories 230 – 300 kg (n = 48), 301 – 350 kg (n = 46) and 351 – 500 kg (n = 42). The carcasses were classed in conformation class "R" and fatness class "2". The bulls were also divided into three groups on the basis of average daily gain. The average daily gain ranged from 437 to 550 $g \cdot day^{-1}$ in group 1 (n = 41) and from 551 to 660 $g \cdot day^{-1}$ in group 2 (n = 47). The net gain during fattening in group 3 ranged from 601 to 880 $g \cdot day^{-1}$ (n = 48). Analysis was performed on samples of *Musculus longissimus thoracis* (MLT) 48 hours *post mortem* taken from the site of the dividing cut at the level of the 9th and 10th thoracic vertebrae.

Selected technological quality indicators [the water-holding capacity of the meat determined by a modified Grau and Hamm method (1952), the area of MLT determined by planimetry, the pH_{48} measured with a 340/SET-1 pH–meter with piercing probe (WTW, Germany) and the muscle fibre diameter evaluated with microscope equipment and software from the company Leica (Leica Microsystems, Germany)] were determined in the beef.

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The following colour indicators were also studied in the meat: the content of muscle pigments determined by the Hornsey method (1956) and CIELab colour system parameters monitoring lightness (L*), redness (a*) and yellowness (b*) determined by a Konica Minolta CM-2600d spectrophotometer (Konica Minolta, Japan). A measuring slit of 8 mm, light source daylight – D65, 10° standard observer angle and SCI mode were all set to ensure standard measurement conditions. The indicators studied were evaluated in dependence on the slaughter age of the bulls, carcass weight and average daily gain.

Statistical data analysis was performed in the program STATISTICA 12.0 (StatSoft, Inc., Tulsa, Oklahoma, USA) using ANOVA to evaluate the effect of the age of the animals at slaughter, the carcass weight and the net gain on the studied indicators of the nutritional quality of the meat. An HSD test was used to determine correspondence between the groups. The calculation equation was:

$$Y_{ijkl} = \mu + V_i + J_j + N_k + e_{ijkl}$$

where:
Y – corrected result value
μ – average value of dependent variable
V_i – age of animals at time of slaughter (1 = 520 – 540 days; 2 = 640 – 760 days)
J_j – carcass weight (1 = 230 – 300 kg; 2 = 301 – 350 kg; 3 = 351 – 500 kg)
N_k – net gain (1 = 437 – 550 g·day^{-1}; 2 = 551 – 600 g·day^{-1}; 3 = 601 – 880 g·day^{-1})
e_{ijkl} – residual

Results and Discussion

A description of the indicators of the technological value and colour of the meat of the bulls is given in Table 1.

Table 1. Indicators of the technological value and colour of the meat of bulls according to age at slaughter

Age at slaughter [days]	520 – 540		640 – 760	
Number of animals	95		41	
Factor	LMS	SE	LMS	SE
	Technological value of meat			
Water holding capacity [%]	81.63	0.51	81.48	0.31
MLT area [cm^2]	80.48^A	12.15	102.83^B	13.94
pH_{48}	5.75^A	0.04	5.56^B	0.01
Muscle fibre diameter [μm]	39.55^A	1.52	40.70^B	1.85
	Meat colour parameters			
Pigments [mg·g^{-1}]	3.65^A	0.06	4.43^B	0.09
L*	34.29	0.35	33.13	0.32
a*	8.99^A	1.60	10.68^B	1.23
b*	7.77	1.52	7.74	1.15

Statistical significance between evaluated groups of bulls: A, B = $p < 0.01$
LMS – Least Mean Squares; SE – Standard Error

The average water-holding capacity found in the meat of bulls slaughtered at an age of between 520 and 540 days was 81.63%. Extending the fattening period (640 – 760 days) resulted in a fall in the water-holding capacity of beef meat (81.48%), though no statistically conclusive difference between the age categories was proven ($p > 0.05$). Šubrt et al. (2009) analysed the meat of bulls of various breeds. The water-holding capacity of the meat of Czech Fleckvieh bulls slaughtered at the age of 622 days was 78.22%. The area of MLT (cm^2) increased statistically conclusively with the age of the animal ($p < 0.01$) from 80.48 cm^2 in bulls slaughtered at the age of 520 – 540 days to as much as 102.83 cm^2 in bulls slaughtered at the age of 640 – 760 days. Filipčík et al. (2010) state in their work that the area of MLT grew linearly with the increasing weight of the animal (90.3 < 97.2 < 99.7 cm^2). A significant difference ($p < 0.01$) was found between the age

categories in the value of pH_{48}, with the pH_{48} falling from 5.75 to 5.56 with increasing age. A statistically conclusive difference ($p < 0.01$) was found in the muscle fibre diameter, which increased from 39.55 ± 1.52 μm (520 – 540 days) to 40.70 ± 1.85 μm (640 – 760 days) with a longer fattening period. Němcová et al. (2010) found that increasing age (up to 530 days, 531 – 600 days, more than 601 days) was accompanied by linear growth in fibre thickness (37.86 – 38.33 – 39.81 μm).

Increasing slaughter age had a significant ($p < 0.01$) effect on the content of pigments in the meat, with the content of muscle pigment being 3.65 ± 0.06 $mg \cdot g^{-1}$ at the age of 520 – 540 days and 4.43 ± 0.09 $mg \cdot g^{-1}$ in animals slaughtered at the age of 640 – 760 days. Redness a* also increased significantly ($p < 0.01$) from 8.99 to 10.68 with an extended fattening period. An inconclusive fall ($p > 0.05$) in the values of the parameters lightness L* and yellowness b* was recorded with the increasing slaughter age of the animals (from L* 34.29; b* 7.77 to L* 33.13; b* 7.74). Šubrt et al. (2008) state that a greater age in bulls before slaughter has the effect of significantly ($p < 0.05$) increasing the content of muscle pigments.

No conclusive difference ($p > 0.05$) was found when the effect of carcass weight on the water-holding capacity of the meat was evaluated. The water-holding capacity of the meat ranged from 81.49% to 81.76% (Table 2). The area of MLT increased significantly ($p < 0.01$) with increasing carcass weight (78.04 < 83.39 < 101.90 cm^2). In contrast, the value of pH_{48} fell with increasing carcass weight. The value of pH_{48} showed a highly statistically significant difference ($p < 0.01$) between the lowest carcass weight (5.77 ± 0.06) and the highest carcass weight (5.56 ± 0.01) and a significant difference ($p < 0.05$) between the highest carcass weight and the carcass weight category from 301 to 350 kg (5.74 ± 0.05). The muscle fibre diameter grew with increasing carcass weight, though a highly statistically significant difference ($p < 0.01$) was recorded only between the weight categories 230 – 300 kg (39.29 μm) and 351 – 500 kg (40.65 μm).

Increasing carcass weight had a significant ($p < 0.01$) effect on the pigment content in the meat (3.56 < 3.73 < 4.43 $mg \cdot g^{-1}$) and redness a* (8.92 < 9.01 < 10.69). The values of both these parameters increased and the colour of the meat was darkest in carcasses weighing between 351 and 500 kg. Vieira et al. (2006) found a muscle pigment content of 5.03 ± 0.99 $mg \cdot g^{-1}$ in animals weighing 489.4 kg. The parameter lightness L* also demonstrated the darkest meat colour, although inconclusively ($p > 0.05$), in the heaviest carcasses, with the value of L* falling with an increasing carcass weight. Yellowness b* ranged from 7.65 to 7.82 and no significant differences were demonstrated.

Table 2. Indicators of the technological value and colour of the meat of bulls according to carcass weight

Carcass weight [kg]	230 – 300		301 – 350		351 – 500	
Number of animals	48		46		42	
Factor	LM	SE	LMS	SE	LMS	SE
	Technological value of meat					
Water holding capacity [%]	81.51	0.76	81.76	0.70	81.49	0.30
MLT area [cm^2]	78.04^{A}	13.28	83.39^{A}	11.52	101.90^{B}	13.90
pH_{48}	5.77^{A}	0.06	5.74^{a}	0.05	5.56^{Bb}	0.01
Muscle fibre diameter [μm]	39.29^{A}	1.62	39.84	1.38	40.65^{B}	1.84
	Meat colour parameters					
Pigments [$mg \cdot g^{-1}$]	3.56^{A}	0.09	3.73^{A}	0.08	4.43^{B}	0.09
L*	34.45	0.52	34.00	0.49	33.30	0.33
a*	8.92^{A}	1.47	9.01^{A}	1.72	10.69^{B}	1.22
b*	7.82	1.45	7.65	1.61	7.81	1.16

Statistical significance between evaluated groups of bulls: A, B = $p < 0.01$; a, b = $p < 0.05$

LMS – Least Mean Squares; SE – Standard Error

An evaluation of the technological quality and colour of the meat of bulls in dependence on the level of average daily gain is given in Table 3. Net gain was not found to have an influence ($p > 0.05$) on water-holding capacity. The water-holding capacity of the meat ranged from 81.45% to 81.83%. An increasing level of average daily gain was accompanied in the meat by an evident growth in the area of MLT ($79.34 < 86.09 < 95.06$ cm^2); a highly statistically significant difference ($p < 0.01$) was demonstrated between the group with a net gain of 601 – 880 g·day^{-1} and the group with a net gain of 437 – 550 g·day^{-1} and the group with a net gain between 551 and 600 g·day^{-1}. Although a fall in the value of pH_{48} ($5.78 > 5.69 > 5.63$) was recorded in connection with the increasing level of average daily gain, net gain was not proven to have an effect ($p > 0.05$). A difference at the 99% level of significance was found in the muscle fibre diameter between the groups with the lowest (39.22 ± 1.66 μm) and highest (40.26 ± 1.65 μm) net gain, while differences at the 95% level of significance were evident between the group with an average daily gain between 551 and 600 g·day^{-1} (40.12 ± 1.65 μm) and the group with the lowest net gain.

An increase in the values of muscle pigment content and redness a* was recorded with an increasing level of net gain (pigments $3.62 < 3.90 < 4.09$ mg·g^{-1} and a* $8.99 < 9.35 < 10.07$), though a statistically significant difference ($p < 0.01$) was found only between the groups with the lowest and highest average daily gain. No statistically significant differences ($p > 0.05$) were found for other colour parameters. The values of the parameter lightness L* ranged from 33.51 to 34.17, while yellowness b* ranged from 7.58 to 7.93.

Table 3. Indicators of the technological value and colour of the meat of bulls according to level of average daily gain

Average daily gain [g·day^{-1}]	437 – 550		551 – 600		601 – 880	
Number of animals	41		47		48	
Factor	LMS	SE	LMS	SE	LMS	SE
			Technological value of meat			
Water holding capacity [%]	81.83	0.85	81.45	0.58	81.52	0.49
MLT area [cm^2]	79.34^{A}	15.83	86.09^{A}	12.14	95.06^{B}	17.01
pH_{48}	5.78	0.06	5.69	0.04	5.63	0.04
Muscle fibre diameter [μm]	39.22^{Aa}	1.66	40.12^{b}	1.65	40.26^{B}	1.65
			Meat colour parameters			
Pigments [mg· g^{-1}]	3.62^{A}	0.11	3.90	0.11	4.09^{B}	0.09
L*	34.16	0.58	33.51	0.31	34.17	0.49
a*	8.99^{A}	1.43	9.35	1.82	10.07^{B}	1.61
b*	7.72	1.53	7.58	1.29	7.97	1.44

Statistical significance between evaluated groups of bulls: A, B = $p < 0.01$; a, b = $p < 0.05$

LMS – Least Mean Squares; SE – Standard Error

Conclusions

The results indicate that the area of MLT (cm^2) and the muscle fibre diameter (μm) increased with the age of the animal. The meat of older animals contained more muscle pigment.

The age-related weight of the animal saw a corresponding trend in the growth of the area of MLT (cm^2) and the muscle fibre diameter (μm). In contrast, the pH of the meat fell with the age and weight of the animal. The content of muscle pigment increased with the growing weight of the animals.

The average daily gain was also proven to have an effect on the area of MLT (cm^2) and the muscle fibre diameter (μm). The amount of pigments in the meat and the redness of the meat increased as a result of the level of net gain.

The overall evaluation of colour parameters in meat indicates that the meat of older animals of greater weight is darker.

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