Carcass and meat quality of the most numerous slaughtered cow breeds in Slovakia

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Summary
The objective of this study was to compare the quality of cow carcasses and meat of three most slaughtered breeds in Slovakia: Black Holstein (BH, $n = 119$) and Red Holstein (RH, $n = 86$), and Slovak Simmental (SS, $n = 83$). A total of 288 samples of meat were collected randomly from cows from various slaughterhouses in Slovakia. All animals were fed the Total Mixed Ration diet year round. At slaughter, the cows were 2 094.40 ± 928.07 days old. Higly significant differences were found in the age ($p < 0.001$). At slaughter, SS cows were 18 months older than RH and 23 months older than BH. SS showed the highest score of carcass conformation (1.58 ± 0.59), the differences in carcass conformation being statistically significant ($p < 0.05$). Meat quality showed statistically significant differences among the breeds in content of proteins ($p < 0.01$), fat ($p < 0.05$) and in Warner-Bratzler shear force of grilled meat ($p < 0.001$). The highest content of proteins (24.5 %) was determined in RH and the highest content of fat was determined in BH (4.2 %). In the SS group, meat was characterized by a higher level of shear force (19.55 kg). SS had the lightest colour of meat ($L^* = 30.26$).

Keywords
carcass; meat; quality; culled cows; Holstein; Simmental

In contrast to other animal species, cattle provide meat for processing and direct consumption from several categories (bulls, cows, steers, heifers, calves). Each category is characterized by specific meat with a wide range of quality characteristics for carcass as well as the meat itself.

Concerning the total number of animals kept, as well as other livestock, half of the population is made up of female animals. This fact raises a question regarding the definition of quality and the possibility of marketing meat cows, which are still considered inferior and of lesser quality [1]. Although culled cows are primarily a by-product of an industry dedicated to producing grain-fed, A-maturity beef [2], they are still a valuable resource to producers and account for 15–20 % of total revenues [3].

Dairy farms produce, directly or indirectly, one third of beef and veal meat produced in EU. Based on the calculations of KOUCKÝ and KUDRNA [1], in the Czech Republic cow meat represents more than one third of beef consumption per inhabitant and year out of total annual beef consumption. Similar situation is seen in Slovakia as well. In fact, approximately 43 % of slaughtered cattle are culled cows (31 % dairy cows, 12 % beef cows). Nowadays, cows represent the most numerous category of slaughtered cattle at abattoirs in Slovakia. Cows are culled for various reasons including age, poor performance or failure to reproduce [4]. Meat from dairy cows often has the reputation of being very tough and coming from older animals [5].

In Slovakia, the daily diet of cows in the dairy system consists mainly of the year-round Total Mixed Ration feeding. The most common dairy

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breed is Black Holstein with a proportion of 45 %, followed by Slovak Simmental as a dual-purpose breed, with a proportion of 33 %, and the dairy breed Red Holstein with a proportion of 16 %. This fact determined our orientation to the above mentioned breeds. The objective of this study was to compare the quality characteristics of cow carcasses and meat of these three most slaughtered breeds in Slovakia.

MATERIAL AND METHODS

Animals performance and slaughter characteristics

In total, 288 samples of cow meat were collected randomly from various slaughterhouses located in all regions of Slovakia. Animals originated in various dairy farms in Slovakia. All animals were fed the Total Mixed Ration diet year round. This system is traditionally used in Slovakia to feed dairy cows. The composition of the breeds in the study reflected the dairy herd structure and the structure of animals slaughtered in the slaughterhouses in Slovakia. The breed composition was as follows: Black Hosltein (BH, n = 119) and Red Holstein (RH, n = 86) as dairy breeds and Slovak Simmental (SS, n = 83) as a dual-purpose breed. The age of the cows was 2094.40 ± 928.07 days (equal to 5.7 years or 69 months). The carcasses were classified by SEUROP classification system for beef carcass according to Regulation No. 206/2007 [6]. Due to the change of character marking of classes for carcass conformation to a numeric scale, the transformation was set as follows: P = 1, O = 2, R = 3, U = 4, E = 5. The scale for fatness score was used directly, 1 for the lowest fat level to 5 for the highest fat level. The carcasses were weighed and the carcass weight in kilograms was converted to live weight using a coefficient of 1.93 for cows. No Animal Care and Use Committee approval was needed because meat samples used in this study were taken from carcasses from commercial slaughterhouses.

Muscle sampling and analyses

Meat samples from *musculus longissimus thoracis et lumborum* (sirloin steak) were taken 48 h after slaughter from the chilled right carcass sides between 9th and 11th ribs. The average weight of a sample was between 800 g and 1000 g. Each sample was hygienically packed and transferred to the Laboratory of meat quality of the Research Institute for Animal Production in Nitra (Slovakia) in a portable refrigerator at a temperature of T = 4 °C.

Within the same day (48 h after slaughtering), the pH values (marked as pH_{48}) were measured using a glass electrode with a portable pH meter (type 3071; Jenway, Cambridge, United Kingdom).

Degree of marbling was sensorically determined on the basis of a 9-point marbling scale according to Canadian Beef Grading Agency [7], where 1 means abundant and 9 means practically devoid.

Water holding capacity (*WHC*) was analysed using the method of Grau and Hamm [8].

After the determination of pH_{48}, the degree of marbling and *WHC* of each sample was divided into two parts.

The values of meat colour, the parameters $L^*a^*b^*$, were analysed by spectrophotometry on the cutting area of the sample using the device Miniscan XE Plus (Hunter Associates Laboratory, Reston, Virginia, USA). The lightness L^* is represented along the vertical axis and varies from 0 (dark) to 100 (white). The a^* value is represented on the X axis; it corresponds to the green/red opponent colours with green at negative and red at positive a^* values (scale from –60 for green to +60 for red). The b^* value is represented on the Y axis and corresponds to the blue/yellow opponent colours with blue at negative and yellow at positive b^* values (scale from –60 for blue to +60 for yellow). In the centre of the colour space (values of $a^* = 0$ and $b^* = 0$) is the neutral gray.

A muscle sample of 100 g was homogenized for determination of basic chemical composition (total water, proteins and fat content) and, subsequently, analysed by Infratec 1265 Meat Analyser (Tecator, Höganäs, Sweden). Second part of the sample was wrapped into polyethylene foil wrapping bags and stored for 7 days in a refrigerator at a temperature of T = 4 °C. After 7 days, the matured meat samples were cut into slices 2.5 cm thick and grilled at a temperature of T = 200 °C for 4 min using an electrical contact grill Model PM-1015 (RM Gastro, Praha, Czech Republic). The meat sample was weighted before and after grilling and the cooking loss was determined. The Warner-Bratzler shear force of grilled meat was measured in grams and converted to kilograms in the Texture Analyser TA.XT2i (Stable Microsystems, Godalming, United Kingdom).

Statistical analysis

The basic statistical procedures as well as correlation calculation and one-way analysis of variation (ANOVA) were carried out using the software package Statistical Analysis System (SAS) version 9.2. (SAS Institute, Cary, North Carolina, USA). The factor breed was taken into

acount. One-way ANOVA was performed using the following model:

$$y_{ij} = \mu + \alpha_i + e_{ij} \quad (1)$$

where μ is expected value for all levels of the factor, α_i is effect of *i*-level of factor A and e_{ij} is random error.

RESULTS AND DISCUSION

Basic characteristics of growth performance and slaughter traits of cows are presented in Tab. 1. Higly significant differences were found in the age of slaughtered cows ($p < 0.001$). Bahelka and Gondeková [4] reported similar significant differences in the age at slaughter. On average, the cows were slaughtered at the age of 2094.40 days (5.7 years) or in 3.4 lactations, respectively, in accordance with the average age at first lactation and average days open in Slovakia considering the breed. This confirms the observations of Zaujec et al. [9], who reported a very similar slaughter age of culled cows in Slovakia (6 years). In contrast, Bahelka and Gondeková [4] reported a higher age at slaughter (7.4 years). In our study, the oldest cows were SS and the youngest were BH. SS cows were 18 months older than RH and 23 months older than BH at slaughter. This fact reflects lower longevity in BH cows than in dual-purpose breeds.

In the present study, no significant differences were found in the weight of carcass, converted live weight, fatness and marbling score. However, the tendency of superiority within the SS group in weight of carcass, converted live weight and marbling score was determined. Converted live weight showed that the animals were slaughtered at weight of 487.04 ± 146.49 kg. These results are comparable to those of Bahelka and Gondeková [4] and Mojto et al. [10] who reported slaughter weight of cows in Slovakia of 453.70 kg and 470.61 kg, respectively. Our results are comparable also to those of Méndez et al. [11] who reported, in a survey in Mexico, that 71.6 % of cattle had slaughter weight in the range 400–500 kg.

One way to improve the value of cow carcass is to feed culled cows with an energy-dense diet before slaughter to improve fat colour and palatability, as well as to increase the fat content and lean yields [12]. Unfortunately, the current economic conditions are unfavourable for the domestic dairy cattle breeding and many farms cannot afford special diet for culled cows. Therefore, cows end in a slaughterhouse at the end of the milking period without any fattening period, very often in a bad body condition. The increase in live and carcass weight by high-intensity feeding sytems for culled beef cows was evaluated in several studies [2, 5]. These systems consistently improved carcass characteristics [13]. Pritchard and Burg [14] indicated that feeding for 60–100 days is required for most cows to improve by one slaughter grade (from P to O), particularly when exposed to high dietary energy. Additionally, Apple [15] found that culled cows with body condition score of 6 had the highest economic value to producers and packers. In our study, the distribution of carcass conformation scores showed that there is a considerable room for improvement regarding this trait. However, costs for fattening should be covered by revenues of surplus sold live weight and carcass conformation.

In general, we can negatively assess the meat contents in carcasses of the slaughtered cows, as most of them were classified in the worst classes for carcass conformation, O and P, or 2 and 1 for fatness, respectively ($p < 0.05$). Similar results were reported by Zaujec et al. [9], Mojto et al. [10] and Gondeková et al. [16]. Moon et al. [17] did not find statistically significant differences among groups of slaughter cows while evaluating the quality of carcass (the so called "yield grade"), the cows being divided into three age groups (young, medium old and old).

Minchin at al. [18] observed the effect of increasing energy density of the pre-slaughter diet on days to slaughter, average daily gain, as well as final live animal and carcass characteristics of spring calving culled dairy cows fed to a predetermined live weight and body condition score. Important differences were found between young (primiparous) and old cows (seven lactations or greater), where young cows had the greatest capability of responding to finishing diets due to superior average daily weight gain (ADG) and were likely to be a more viable option for this procedure. The results were comparable with those of Pritchard and Burg [14] and Sawyer et al. [3] who observed similar trends in feedlot performance of culled cows, with feedlot performance decreasing as age increased.

Méndez et al. [11] reported that in 82.4 % of the carcasses (young bulls and heifers) the conformation score was 3, 2 or 1, corresponding to the categories good, normal and poor, respectively, within the Mexican survey. The median conformation score was 3. This conformation score was higher than in our study, which might have been caused by the use of approved growth promoters like zilpaterol chlorhydrate (Zilmax; Intervet/Schering-Plough Animal Health, Estado de Me-

xico, Mexico), known for its positive influence on carcass yield [19]. The use of growth promoters is strictly prohibited in livestock farming in the EU countries.

Differences in fatness were minimal among the breed groups and, on average, near 2nd class of fatness score, which means moderate degree of fatness in carcass. In general, high levels of surface fat correspond to high content of intramuscular fat. In our study, there were minimal differences between breeds in fatness and in marbling score, but Holstein cows had the highest fatness score and the most marbled meat as well. The average marbling score was 7.63, characterized as slight or trace degree. From the obtained results it appears that, in Slovakia, animals with markedly lower content of intramuscular fat are killed than e.g. in USA. It can be related to the fact that customers in Slovakia prefer meat with a lower content of intramuscular fat [9]. Review by KAMENÍK [20] confirmed that consumers nowadays require lean meat with a minimum content of surface fat and adjacent connective tissues such as fasciae and tendons. Our results are comparable with those of BAHELKA and GONDEKOVÁ [4], ZAUJEC et al. [9] and MOJTO et al. [10].

Results on meat quality characteristics are presented in Tab. 2. Meat quality of slaughtered cows, in a strict sense, is expressed as a set of qualitative parameters. Meat consists of many substances, though mostly of water and proteins. In lean meat, water represents approximately 70–75 % of weight, proteins approximately 20 % [20]. On average, the water content in our study was higher (74.7 %) than the value reported by BAHELKA and GONDEKOVÁ [4] and GONDEKOVÁ et al. [16]. The water percentage determined by FIEMS et al. [21] in Belgian Blue double-muscled cows as well as SCHNELL et al. [12] in cows with varying genotypes was lower. In contrast, ZAUJEC et al. [9] reported higher water content (75 %) in culled cows of various breeds. In our study, higher water content was found in samples of SS than in dairy BH and RH (75.2 % vs 74.5 %). Similar difference was reported by SCHNELL et al. [12] who found higher moisture content in carcass soft tissues in European cow carcasses than in dairy cows. HOFFMAN [22] observed lower moisture value (73.5 %) in Simmental culled cows than the value determined in our study.

The highest intramuscular fat content (4.2 %) and the least protein percentage (20.3 %) were found in samples of BH. The least intramuscular fat (2.9 %) was recorded in SS. This is comparable with the results of HOFFMAN [22] who reported lower soft tissue fat of Continental European cull cows than in dairy (Holstein, Brown Swiss), Brahman-crossbred and British breed types. In concurrence with the result from our study, KOUCKÝ et al. [23] reported a higher fat content in Czech Simmental cows than in Holstein cows. On average, we determined lower values of intramuscular fat in all samples of cow meat (3.8 %) than GONDEKOVÁ et al. [16] (3.9 %), FIEMS et al. [24] (7.7 %) but higher than ZAUJEC et al. [9] and BAHELKA and GONDEKOVÁ [4] (3.5 %). Even lower fat content was observed in the studies of HOFFMAN [22] (1.7 %), KOUCKÝ et al. [23] (1.3 %) or FIEMS et al. [21] (2.3 %) in Belgian Blue cows. The higher water content determined in SS might have been caused by the lowest fat content.

The pH_{48} value was similar for all breed groups (5.8). The lowest identical value of pH_{48} was determined in RH and SS samples. On average, no deviations in meat quality e.g. dark firm dry (DFD, over pH_{48} 6.2) occurred in any of the breed types. ZAUJEC et al. [9] and GONDEKOVÁ et al. [16] observed higher pH_{48} values than in our research work (5.9). It is well known that colour is the first attribute of physical quality that influences a consumer's buying decision. HUGHES et al. [25] considered that the most important traits of meat are its colour, tenderness and *WHC*. *WHC* expresses the ability of fresh meat to retain its own water during cutting, warming, grinding and pressing, and also during transportation, storage and heat processing. In our study, *WHC* ranged from 28.2 % to 28.4 %. The differences were not significant among the breeds. Our results are comparable with BAHELKA and GONDEKOVÁ [4], while ZAUJEC et al. [9] found lower values (26 %). In general, it is valid that meat with low *WHC* tends to produce inferior yields and lower quality of processed meat. An association between higher pH values and darker meat (lower L^* values) was reported by FALTA and CHLÁDEK [26]. PEARSON and YOUNG [27] observed higher *WHC* in comparison to our study. The brightest meat was that of SS and the darkest that of RH, while the pH_{48} value was similar for all breed groups.

In cattle, meat from dairy breeds is usually redder than the meat from beef breeds when compared at a similar age, due to the higher proportion of oxidative muscle fibres in the earlier maturing dairy breeds [28]. This fact was confirmed in our findings. MOON et al. [17] reported higher L^* values in Hanwoo beef females (34.4; 35.5 and 35.6). Their results are in contrast with the result of our study and the studies of BAHELKA and GONDEKOVÁ [4], ZAUJEC et al. [9] and MOJTO et al. [10] as well.

Generally, tenderness is considered one of the

Tab. 1. Basic characteristics of growth performance and slaughter traits of cows.

Parameter	All data (n = 288)	Black Holstein (n = 119)	Red Holstein (n = 86)	Slovak Simmental (n = 83)	f-test	t-test		
						BH : RH	BH : SS	SS : RH
Age [d]	2094.40 ± 928.07	1846.72 ± 766.71	2000.16 ± 853.61	2552.66 ± 1052.62	***	ns	**	ns
Weight of carcass [kg]	251.05 ± 75.51	254.18 ± 67.75	243.08 ± 77.66	254.83 ± 83.70	ns	ns	*	ns
Converted live weight [kg]	487.04 ± 146.49	493.11 ± 131.43	471.57 ± 150.66	494.37 ± 162.37	ns	ns	*	ns
Conformation score	1.47 ± 0.58	1.45 ± 0.61	1.40 ± 0.54	1.58 ± 0.59	*	ns	ns	ns
Fatness score	1.93 ± 0.92	2.00 ± 0.92	1.86 ± 0.95	1.90 ± 0.88	ns	ns	ns	ns
Marbling score	7.63 ± 1.56	7.51 ± 1.75	7.63 ± 1.41	7.81 ± 1.40	ns	ns	*	ns

Values are expressed as mean ± standard deviation, n – number of samples. Significance: ns – not significant efect, $p > 0.05$, * – $p < 0.05$, ** – $p < 0.01$, *** – $p < 0.001$.
Conformation score according SEUROP system [6]: P = 1 (very poor), O = 2, R = 3, U = 4, E = 5 (very good). Fatness score acording to SEUROP system [6]: 1–5 scale (1 – low fatness, 5 – high fatness). Marbling score acording to Canadian Beef Grading Agency [7]: 1–9 point marbling scale (1 – abundant, 9 – practically devoid).

Tab. 2. Meat quality characteristics.

Parameter	All data (n = 288)	Black Holstein (n = 119)	Red Holstein (n = 86)	Slovak Simmental (n = 83)	f-test	t-test		
						BH : RH	BH : SS	SS : RH
Water [%]	74.7 ± 3.3	74.5 ± 3.6	74.5 ± 3.4	75.2 ± 2.7	ns	ns	*	ns
Protein [%]	20.5 ± 1.1	20.3 ± 1.2	24.5 ± 1.0	20.9 ± 1.2	**	*	ns	ns
Fat [%]	3.8 ± 3.2	4.2 ± 3.4	4.1 ± 3.5	2.9 ± 2.4	*	ns	***	**
pH_{48}	5.8 ± 0.4	5.8 ± 0.4	5.8 ± 0.4	5.8 ± 0.4	ns	ns	ns	ns
L^* colour scale	29.9 ± 3.5	29.8 ± 3.4	29.8 ± 3.7	30.3 ± 3.4	ns	ns	ns	ns
a^* colour scale	11.4 ± 2.6	11.2 ± 2.3	11.0 ± 2.5	11.3 ± 2.9	ns	ns	**	ns
b^* colour scale	7.3 ± 1.6	7.7 ± 1.6	7.1 ± 1.7	7.4 ± 1.5	ns	ns	ns	ns
Water holding capacity [%]	28.3 ± 6.2	28.3 ± 5.9	28.2 ± 6.0	28.4 ± 6.0	ns	ns	ns	ns
Warner-Bratzler shear force [kg]	16.7 ± 9.6	14.5 ± 8.3	17.0 ± 10.1	19.6 ± 10.3	***	ns	*	ns

Values are expressed as mean ± standard deviation, n – number of samples. Significance: ns – not significant efect, $p > 0.05$, * – $p < 0.05$, ** – $p < 0.01$, *** – $p < 0.001$.
pH_{48} – pH 48 h after slaughtering, L^* colour scale – lightness (0 – black, 100 – white), a^* colour scale – redness/greenness (positive values – red, negative values – green), b^* colour scale – yellowness/blueness (positive values – yellow, negative values – blue).

major characteristics of meat quality together with *WHC*. It is noteworthy that consumer's willingness to pay more for premium tender meat is also reported in literature [29]. The finest meat, meat with the lowest Warner-Bratzler shear force of grilled meat, was determined for BH samples and the highest in SS. FRANCO et al. [30] found lower Warner-Bratzler values in Holstein cows on the 7th day of aging. MOJTO et al. [10] and BAHELKA and GONDEKOVÁ [4] identified the finest meat in cows in the same order as in our study. The highest Warner-Bratzler values might have been caused by the higher age at slaughter in SS than in BH, the difference between those breeds being 5.08 kg. However, Warner–Bratzler value in BH after 7 days of aging was still very high, avoiding the sample to be used as a retail product. We suggest that, in order to use cow meat as a retail product for grilling, it is necessary to prolong its ageing to more than a 4-week time period. Regarding cattle breeding and meat processing in Slovakia, more detailed research needs to be done to prove the hypothesis SS, as a dual-purpose breed with the ability to produce better carcass, might provide better quality than specialized dairy breeds mostly regarding carcass conformation and fatness level. Cows in a better body condition, with a higher live weight and fattnes are selected for export abroad to countries such as Austria, Hungary, Poland or Turkey. There our farmers make a higher profit than in Slovakia.

CONCLUSIONS

Holstein – black and white, Red Holstein and Slovak Simmental are the most slaughtered cow breeds in Slovakia. In general, we can negatively assess their meat content, as most of the carcasses were classified in the worst classes of meat, O and P, and the marbling corresponded to the slight or trace categories. One way to improve the carcass characteristics is to feed culled cows with energy-dense diet before slaughter. Slovak Simmental cows had the highest longevity, which was statistically significant. On the other hand, older animals had tougher meat as was statistically confirmed by the Warner-Bratzler shear force, which was highest in SS. We suggest that, if cow meat is to be used as a retail product for grilling, it is necessary to prolong its ageing to more than a 4-week time period. Regarding cattle breeding and meat processing in Slovakia, more detailed research needs to be done to prove the hypothesis.

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