CARCASS AND MEAT QUALITY CHARACTERISTICS OF YOUNG BLACK-AND-WHITE AND RED-AND-WHITE HOLSTEIN-FRIESIAN BULLS

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Abstract. The objective of this study was to determine carcass and meat quality characteristics of young Black-and-White and Red-and-White Holstein-Friesian bulls. The study involved 98 young Polish Holstein-Friesian bulls, including 53 Black-and-Whites and 45 Red-and-Whites, fed high-concentrate diets. The bulls were slaughtered at approximately 570 kg BW, and carcass quality was evaluated. The average daily gains of intensively fed Red-and-White and Black-and-White Holstein-Friesian bulls were high, at 1270 g and 1200 g respectively. The average carcass dressing percentage was similar in bulls of both groups, exceeding 55%. Red-and-White bulls had a higher percentage share of carcasses in conformation classes R, R- and O+. The carcasses of Black-and-White bulls had a higher proportion of forepart cuts, i.e. fore ribs, thin flank and shoulder muscles, and a lower proportion of meat of quality classes I and II, and bones. The meat of intensively fed Holstein-Friesian bulls from both groups was characterized by good quality. As many as 95% of beef samples had pH below 5.80 and could undergo ripening. An analysis of the physicochemical properties of meat showed no significant differences between groups. Meat from Red-and-White bulls received significantly higher scores for taste and juiciness in an organoleptic evaluation.
Keywords: young bulls, slaughter value, meat quality.

HOLŠTEINO FRYZŲ JUODMARGIŲ IR ŽALMARGIŲ BULIUKŲ SKERDENOS IR MĖSOS KOKYBĖS CHARAKTERISTIKOS

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Santrauka. Tyrimo tikslas – nustatyti Holšteino fryzų juodmargių ir žalmargių buliukų skerdenos ir mėsos kokybės charakteristikas. Tyrimui atrinkti 98 Holšteino fryzų buliukai – 53 juodmargiai ir 45 žalmargiai, kuriems taikyta didelės koncentracijos dieta. Buliukai paskersti, kai svėrė apie 570 kg. Įvertinta skerdenos kokybė. Intensyviai šeriamų Holšteino fryzų juodmargių ir žalmargių buliukų vidutinis dienos prieaugis buvo didelis – atitinkamai 1270 g ir 1200 g. Abiejų buliukų grupių skerdenos kiekis buvo toks pats – viršijo 55 proc. Žalmargių buliukų procentinė R, R- ir O+ klasės skerdenos dalis buvo didesnė. Juodmargių buliukų skerdenoje buvo daugiau priešakinės kūno dalies mėsos, t. y. priešakinių šonkaulių, plonosios šoninės ir pečių raumenų linijos, bet mažiau I ir II kokybės klasės mėsos bei kaulų. Abiejų intensyviai šertų Holšteino fryzų buliukų grupių mėsa buvo geros kokybės. Net 95 proc. jautienos mėginių buvo žemesnės nei 5,80 pH vertės ir buvo tinkami brandinti. Fizinės ir cheminės abiejų grupių buliukų mėsos savybės beveik nesiskyrė. Vertinant organoleptiškai, žalmargių buliukų mėsa buvo žymiai skanesnė ir sultingesnė.
Raktažodžiai: buliukai, skerdenos vertinimas, mėsos kokybė.

Introduction. Due to a slow growth rate of beef cattle, beef production in Eastern Europe relies mostly on dairy cattle breeds. The main dual-purpose cattle breed is the Black-and-White lowland breed with a high percentage of HF genes. According to some authors (Dubicki et al., 1984; Grodzki et al., 1988; Kaczmarek and Jarmuz, 1988; Litwińczuk and Szulc, 2005; Ziemiński, 1991; Ziemiński, 1993), an increase in the percentage of HF genes decreases the slaughter quality of cattle. The Holstein-Friesian cattle population is dominated by Black-and-Whites, but the Red-and-White variety is also present. In most countries, herd books are kept collectively for Black-and-White and Red-and-White cattle referred to as the Holstein-Friesian breed in two colour varieties, black-and-white and red-and-white (Litwińczuk, 2005; Park, 2001). Black-and-White cows are characterized by an insignificantly higher milk yield and a lower milk fat content (Litwińczuk, 2005, Ziemiński, 2001). According to Litwińczuk (2005), the advantage of Black-and-Whites over Red-and-Whites is a slightly higher protein content of milk and a higher frequency of the κ-casein B allele. Available literature

provides scanty information on cattle with the B allele as κ-casein is better suited for cheese production. There is a scarcity of published data on the slaughter quality of Black-and-White and Red-and-White cattle. Previous research (Laurans, 1991), regarding cattle with a low percentage of HF genes, showed no significant differences between bulls of both colour varieties with respect to carcass quality traits.

The objective of this study was to determine carcass and meat quality characteristics of young Black-and-White and Red-and-White Holstein-Friesian bulls.

Material and Methods. The study involved 98 young Holstein-Friesian bulls, including 53 Black-and-Whites and 45 Red-and-Whites. From 106 kg to 220–250 kg BW, the bulls were fed feed concentrate (ad libitum) and meadow hay at 1–1.5 kg. Experimental fattening was carried out from 250 kg to approximately 570 kg BW. Over this period, the bulls were fed complete diets formulated according to the changing body weight of animals.

During fattening from 250 kg to 400–420 kg BW, control group bulls were fed a concentrate diet containing 32% corn, 20% wheat mix, 24% barley, 5.3% wheat bran and 16% rapeseed meal. The feed concentrate for experimental group bulls was composed of 30.5% corn, 18% wheat mix, 20% barley and 5.3% wheat bran, and it was supplemented with 23.5% corn DDGS.

At the final stage of fattening, from 400–420 kg to 570 kg BW, the young bulls received diets with a decreased protein content. The feed concentrate for the control group contained 33% corn, 23% wheat mix, 27% barley, 5.3% wheat bran and 9% rapeseed meal. The diet for the experimental group was composed of 32% corn, 23% wheat mix, 25.7% barley, 5.3% wheat bran and 11.3% DDGS. All concentrate diets were supplemented with 0.5% NaCl, 1.7% limestone and 0.5% premix for beef cattle. The chemical composition of corn DDGS was as follows: dry matter – 93.30%, crude ash – 5.26%, crude protein – 24.31%, crude fiber – 7.45%, crude fat – 10.45%.

Table 1. **Feeding scheme for intensively fattened young bulls** (determined for daily gains of 1100 - 1300 g)

Body weight (kg)	Feed concentrate (kg)	Hay + straw (kg)	Body weight (kg)	Feed concentrate (kg)	Hay + straw (kg)
200–250	4.3	1.2	400–450	6.7	1.6
250–300	4.9	1.4	450–500	7.4	1.8
300–350	5.5	1.4	500–550	8.1	1.8
350–400	6.1	1.6	550–600	8.9	1.8

The animals were fed according to the above scheme, and the amount of feed concentrate for both groups was determined each day. Straw was supplied at around 1.5 kg per head. Straw intake could be higher as the bulls were kept in pens bedded with straw.

At the end of fattening, the bulls were transported to the meat processing plant where they stayed in the lairage for 20 hours prior to slaughter. The carcasses were chilled for 48 hours at around 2^0C. Chilled right half-carcasses were weighed and divided into retail cuts according to the rules of English market (so-called London method – not published, details are available at authors). The following retail cuts were obtained: shoulder, best end of the neck, fore ribs, best ribs, thin flank, brisket, sirloin, rump, thick flank, topside, silverside plus bavette plus gastrocnemius muscle, loin, flank, shank, shin. The external fat layer was not removed.

Meat of quality class I (lean), II (medium-fat), III (stringy) and IV (with traces of blood), fat, tendons and bones were also obtained. The retail cuts from the right half-carcasses were weighed and their percentage share of the total carcass weight was calculated. The price of 100 kg beef carcass divided into retail cuts was determined based on the official wholesale beef-cut prices quoted over the research period.

Samples of *m. longissimus dorsi* were collected from randomly selected loin cuts (between the 11^{th} and 13^{th} thoracic vertebra) to evaluate meat quality; 53 and 45 meat samples were collected in the group of Black-and-White and Red-and-White bulls, respectively. A qualitative analysis was performed 72 hours post mortem. Meat samples were assayed for: the content of dry matter, fat, total protein and ash (Budsławski, 1972), water-holding capacity by the Grau and Hamm method (1953), pH, and colour in the CIE Lab system. The sensory properties (aroma, taste, juiciness, tenderness) of cooked meat were assessed on a five-point scale (1 – lowest score, 5 – highest score), as described by Baryłko-Pikielna (2009). Shear force values were also determined (after heat treatment) using a Warner-Bratzler head (500 N, speed 100 mm/min.) attached to an Instron universal testing machine (model 5542).

The results were verified statistically by a one-way analysis of variance (ANOVA), using STATISTICA ver. 9.0 PL software (2009). The significance of differences between means in groups was estimated by Tukey test.

Results and Discussion. In the countries where beef breeds have a low share of the total cattle population, Black-and-White and Red-and-White Holstein-Friesian bulls are used for beef production. In our study, young Holstein-Friesian bulls were intensively fed high-concentrate diets to obtain carcasses and meat of high quality.

Table 2 data show that at the beginning of the experiment Red-and-White calves were by 9.90 kg heavier than Black-and-White calves. The former were fattened for a shorter period of time (by 19 days) than the latter. The differences between groups, regarding the initial body weights of animals and the length of the fattening period, were statistically significant. The final

body weights of bulls were similar in both groups. Black-and-White bulls were characterized by significantly lower live weights at slaughter, due to higher body weight loss during pre-slaughter handling.

The slaughter quality of cattle is considerably affected by the feeding system and daily gains (Jasiorowski, 1996). According to previous research (Jasiorowski, 1996; Wajda, 1998), daily gains of 800 g or higher are required to produce high-quality beef carcasses. In the present study (Table 2), average daily gains were significantly higher in Red-and-White bulls than in Black-and-Whites (1270 g vs. 1200 g). Based on literature data (Heiden, 2007; Jasiorowski, 1996; Kaczmarek, 1988; Wajda, 1998; Wajda, 1984), daily gains can be considered as satisfactory in both groups.

The average carcass dressing percentage was similar in the groups of Black-and-White and Red-and-White young bulls, reaching 55.38% and 55.39%, respectively. The noted values were higher than or comparable to those reported by other authors (Jasiorowski, 1996, Kaczmarek, 1988, Ziemiński, 1993) for young Holstein-Friesian bulls.

Despite the intensive nutritional regime, the majority of carcasses (ca. 90%) were classified to conformation class O (Table 3). Red-and-White bulls had a higher percentage share of carcasses in conformation classes R, R- and O+, and lower in classes O and O-. All carcasses of Red-and-Whites and nearly all carcasses (approx. 97%) of Black-and-Whites were classified to fat classes 2 and 3. The percentage of fat class 3 carcasses was higher in the group of Red-and-White bulls. In a study by Schöne et al. (2006), the carcasses of young Holstein-Friesian bulls were classified to conformation class O3.

Table 2. **Live body weight and carcass weight of young bulls, carcass grades** (EUROP system) **and carcass dressing percentage**

Specification	Polish Holstein-Friesian breed colour variety			
	Black-and-White (69 head)		Red-and-White (45 head)	
	$\bar{x}$	s	$\bar{x}$	s
Bodyweight on the beginning of research (kg)	95.15[a]	19.05	104.24[b]	16.36
Bodyweight on the end of research (kg)	565.71	33.18	571.40	39.39
Length of fattening (days)	371.22[a]	30.77	352.38[b]	29.72
Daily gains (g)	1200[a]	0.14	1270[b]	0.15
Pre-slaughter weight (kg)	536.12[a]	27.41	550.62[b]	38.04
Hot carcass weight (kg)	296.61	18.08	304.94	24.12
Carcass dressing percentage (%)	55.38	2.22	55.39	2.43

Values followed by identical superscripts are significantly different: a, b – $P \leq 0.05$

Table 3. **Conformation and fatness class of carcasses of young bulls according to EUROP grading system**

Specification	Polish Holstein-Friesian breed colour variety	
	Black-and-White (69 head)	Red-and-White (45 head)
Conformation class	Percentage of carcasses	Percentage of carcasses
R	1.45	11.11
R-	4.35	11.11
O+	15.94	31.11
O	68.12	44.44
O-	10.14	2.22
Fat class	Percentage of carcasses	Percentage of carcasses
1	2.90	-
2	60.87	53.33
3	36.23	46.67

The slaughter value of cattle is determined by the proportion of cuts with the highest market value in the total carcass weight. The weight of half-carcasses and the percentage share of retail cuts are shown in Table 4. An analysis of the percentage content of retail cuts in beef half-carcasses revealed that the carcasses of Black-and-White young bulls had a higher proportion of forepart cuts, i.e. fore ribs, thin flank and shoulder muscles, *musculus subscapularis, musculus infraspinatus* and *musculus triceps brachii*. The carcasses of Red-and-White bulls had a higher proportion of loin and *musculus biceps brachii* as well as a higher content of meat of quality classes I and II, and lower bone content.

One of the most important quality attributes of beef is intramuscular fat content which has a beneficial influence on the sensory properties of meat (Park, 2001; Wajda, 1998; Wichłacz, 1998). In our study, the percentage content of intramuscular fat in the meat of Black-and-White young bulls was higher (2.02%) than in the meat of Red-and-White bulls (1.78%), yet the noted differences were statistically non-significant (Table 5). According to Wichłacz et al. (1998), the minimum intramuscular fat content of *m. longissiums dorsi* in young bulls, required to achieve a satisfactory sensory quality of beef, is 1%. The sensory properties of meat can be further improved as this level is exceeded. According to other authors (Bach, 1993; Wajda, 1998), the optimum amount of intramuscular fat to maintain beef tenderness is 2.5% – 4.5%. Previous research results suggest that such a high intramuscular fat concentration is difficult to achieve in

Black-and-White Holstein-Friesian bulls. In this study, the percentage content of dry matter, total protein and ash in the meat of bulls of both colour varieties was similar (Table 5).

One of the main quality characteristics of meat is pH which considerably affects the physicochemical properties (colour, water-holding capacity), sensory attributes (tenderness, juiciness) and shelf-life of meat. In the current study, the average pH values of meat from Black-and-White and Red-and-White young bulls were similar, at 5.64 and 5.62, respectively (Table 5). A detailed analysis of pH levels revealed that in both groups approximately 95% of meat samples had pH below 5.80 which is considered the maximum acceptable value of pH_u in beef intended for human consumption (Bach, 1993; Wajda, 1998).

Meat colour is another important quality attribute and a factor that substantially influences consumer purchase decisions. An evaluation of meat colour in the CIE Lab system showed that there were no significant ($P \leq 0.05$) differences between Black-and-White and Red-and-White young bulls in the average values of parameters L^* (lightness), a^* (redness) and b^* (yellowness). Meat samples collected in both groups were marked by similar average values of water-holding capacity (Table 5).

An organolpetic evaluation of beef samples (Table 5) revealed that meat from Red-and-White young bulls tended to be more tasty and juicy. There were no statistically significant differences between groups with regard to the aroma and tenderness of meat. The absence of differences in the tenderness of meat from Black-and-White and Red-and-White bulls was confirmed by shear force values (Table 5).

Table 4. **Half-carcass weight and percentage share of retail cuts in the carcass of young bulls**

Specification	Polish Holstein-Friesian breed colour variety			
	Black-and-White (69 head)		Red-and-White (45 head)	
	$\bar{x}$	s	$\bar{x}$	s
Half-carcass weight (kg)	145.46	9.16	148.82	11.63
Best end of neck	4.23	0.53	4.07	0.68
Fore ribs	4.12^{a}	0.49	3.84^{b}	0.63
Best ribs	3.03	0.27	3.03	0.30
Thin flank	7.06^{a}	1.10	6.56^{b}	0.95
Brisket	4.48	0.73	4.34	0.68
Musculus supraspinatus	0.93	0.11	0.87	0.21
Musculus infraspinatus	1.32^{aA}	0.17	1.19^{bB}	0.17
Musculus subscapularis	1.07^{a}	0.28	0.90^{b}	0.24
Musculus triceps brachii	3.28^{aA}	0.39	2.94^{bB}	0.32
Musculus biceps brachii	0.64^{aA}	0.14	0.78^{bB}	0.18
Topside	5.55	0.33	5.50	0.27
Silverside + bavette	5.09	0.28	5.18	0.28
Thick flank	3.48	0.19	3.44	0.20
Rump	3.55	0.31	3.47	0.23
Loin	3.15^{aA}	0.35	3.40^{bB}	0.34
Sirloin	1.34	0.12	1.38	0.16
Flank	4.12	0.50	3.97	0.68
Musculus gastrocnemius	1.39	0.11	1.40	0.11
Shank	2.97^{a}	0.21	2.84^{b}	0.25
Class I meat	0.93^{a}	0.21	1.09^{b}	0.44
Class II meat	11.00^{aA}	1.50	12.69^{bB}	2.15
Class III meat	1.17	0.46	1.13	0.64
Class IV meat	0.62	0.33	0.72	0.38
Bones	19.03^{a}	1.25	18.51^{b}	1.18
Fat	5.22	1.10	5.47	1.15
Tendons	1.26	0.20	1.29	0.16

Values followed by identical superscripts are significantly different: a, b – $P \leq 0.05$
Values followed by identical superscripts are significantly different: A, B – $P \leq 0.01$

Table 5. **Proximate chemical composition, physicochemical and sensory properties of meat and shear force values**

Specification	Polish Holstein-Friesian breed colour variety			
	Black-and-White (53 head)		Red-and-White (45 head)	
	$\bar{x}$	s	$\bar{x}$	s
Dry matter (%)	25.43	0.71	25.30	0.70
Fat (%)	2.02	0.65	1.78	0.63
Total protein (%)	23.36	0.60	23.34	0.56
Ash (%)	1.10	0.03	1.09	0.03
pH_u	5.64	0.15	5.62	0.13
Water-holding capacity (cm^2)	5.88	1.06	5.55	1.13
Colour evaluation in the CIELab system:				
L^*	35.77	2.31	36.29	2.28
a^*	17.23	1.41	17.54	1.78
b^*	13.46	1.44	13.64	1.42
Aroma – intensity (points)	3.51	0.55	3.69	0.62
Aroma – desirability (points)	4.92	0.21	4.97	0.17
Palatability – intensity (points)	3.97^{aA}	0.41	4.18^{bB}	0.37
Palatability – desirability (points)	4,84	0.32	4.91	0.22
Juiciness (points)	3.93^{aA}	0.50	4.21^{bB}	0.51
Tenderness (points)	3.63	0.69	3.83	0.63
Shear force (N)	47.53	11.95	46.36	13.28

Values followed by identical superscripts are significantly different: a, b – $P \leq 0.05$
Values followed by identical superscripts are significantly different: A, B – $P \leq 0.01$

Conclusions

1. The average daily gains of intensively fed Red-and-White and Black-and-White Holstein-Friesian young bulls were high, at 1270 g and 1200 g respectively.

2. The average carcass dressing percentage was similar in bulls of both groups, exceeding 55%. Red-and-White young bulls had a higher percentage share of carcasses in conformation classes R, R- and O+. The carcasses of Black-and-White young bulls had a higher proportion of forepart cuts, i.e. fore ribs, thin flank and shoulder muscles, and a lower proportion of meat of quality classes I and II, and bones.

3. The meat of intensively fed Holstein-Friesian young bulls from both groups was characterized by good quality. As many as 95% of beef samples had pH below 5.80 and could undergo ripening. An analysis of the physicochemical properties of meat showed no significant differences between groups. Meat from Red-and-White bulls received significantly higher scores for taste and juiciness in an organolpetic evaluation.

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