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Comparison of meat quality of the Polish Red-and-White and Simmental young bulls

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Abstract: *Comparison of meat quality of the Polish Red-and-White and Simmental young bulls*. The experiment used meat from 16 bulls of the Polish Red-and-White (ZR) (n = 8) and Simmental (SM) (n = 8) breeds. Samples of the *longissimus lumborum* muscle (MLL) were analyzed for basic chemical composition and fatty acid profile of intramuscular fat. Physicochemical and organoleptic properties of meat were evaluated. No differences were found in basic chemical composition of the meat. Intramuscular fat from ZR bulls had a notably lower proportion of polyunsaturated fatty acids (PUFA), but a more favorable n-6/n-3 fatty acids ratio in MLL than meat from Simmental breed. Sensory assessment showed that meat from the conservation breed received higher scores due to greater juiciness, more delicate texture and better aroma.

Key words: cattle, Polish Red-and-White, Simmental, meat, quality

INTRODUCTION

The Polish Red-and-White breed conservation programme, launched in 2007, aims to reestablish dual-purpose cattle suitable for relatively high milk production and capable of profitable rearing of calves and fattening of bulls based on farm-produced feedstuffs. This goal is implemented by gradually decreasing the percentage of Holstein-Friesian blood. Research on the quality of products from local breeds increases the added value, which, in turn, may help to improve the profitability and increase the number of animals from endangered populations. Researchers in many countries have worked on modifying the health-promoting properties through nutrition, management or the use of prolonged fattening (Sargentini et al. 2010 – Maremmana breed), or the physicochemical and organoleptic properties (Marino et al. 2014 – Podolian breed). In recent years, novel research has been done on dairy performance and milk quality (Litwińczuk et al. 2012, Adamska et al. 2014), and fattening capacity and meat quality of conservation breeds, mainly the White-backed and Polish Red (Litwińczuk et al. 2014a, Litwińczuk et al. 2014b, Dymnicki et al. 2014).

Beef from Polish Red-and-White cow was included on 27 June 2013 on the list of traditional products by the Ministry of Agriculture and Rural Development. Although the Polish Red-and-White breed has the best fattening capacity of all conservation breeds of cattle, there are relatively few studies on the meat quality of this breed, despite the changes

that have taken place over the years in research methods, the environment and the genotype of the animals, mainly as a result of the breeding policy.

Simmental cattle are a multipurpose breed that is improved for both milk and meat production and according to Choroszy et al. (2009), it complies with the requirements of the meat industry.

The objective of the study was to determine and compare the meat quality of two dual-purpose breeds: the Polish Red-and-White, included in the conservation programme, and the Simmental.

MATERIAL AND METHODS

Animals and feeding

Subjects were 8 Polish Red-and-White and 8 Simmental bulls. Polish Red-and--White bulls descended from parents qualified for inclusion in the genetic resources conservation programme. Bulls were kept and fed in breed groups. Bulls were fed maize silage and hay, or haylage supplemented with concentrate 2.0 kg per day (88.5% DM, 0.96 UFL, 120 g PDIN, 108 g PDIE). The concentrates fed to the bulls contained soybean meal, rapeseed cake, barley, wheat, triticale, ground limestone, and dicalcium phosphate. Rations were formulated to meet IZ-INRA requirements for weight gains of approx. 1,000 g/day (IZ-INRA 2009). The experiment was terminated after 24 months in summer season and the bulls were subjected to experimental slaughter after 24-hour feed withdrawal. Animals were slaughtered in a commercial EU-licensed abattoir, stunned using captive-bolt pistol and dressed according to commercial practice.

Samples and analysis

Samples of *musculus longissimus lumborum* (MLL) were collected from right side of the carcass chilled at 4 ±1°C for 24 h. The muscle samples were analysed for basic chemical composition using standard AOAC procedures (AOAC 1997). The composition of fatty acids was determined as described by Folch et al. (1957) as methyl esters in hexane by gas chromatography with Shimadzu GC-2010 with Rtx 2330 capillary column (105 m lenght × 0.32 mm internal diameter × 0.2 µ film thickness); injection volume 1.0 µl; temperature programme 60–240°C; injector temperature 250°C; detector temperature 250°C; helium as the carrier gas; according to ISO 12966-2:2011, with slight modifications. Atherogenic index was calculated, according to Ulbricht and Southgate (1991), based on the equation:

$$AI = (C12:0 + 4 \times C14:0 + C16:0) / / (MUFA + PUFA)$$

Cholesterol was determined by gas chromatography with Shimadzu GC-2010 with ZB column (30 m lenght × 0.25 mm internal diameter × 0.5 µ film thickness); injection volume 1.0 µl; temperature programme 100–360°C; injector temperature 250°C; detector temperature 300°C; helium as the carrier gas. The vitamin E was determined using using the high-performance liquid chromatography HPLC technique with fluorescent detection on Merck-Hitachi HPLC system (Darmstadt, Germany). A reverse phase LiChroCART™ 250-4 Superspher™ 100 RP-18 column was used for chromatographic separation. A mixture of methanol and H_2O (96.5 : 3.5 v/v) was used as the eluent (1 mL/min).

The analyses were performed after spectrophotometric standardization of standard ethanol solutions.

Physicochemical and organoleptic evaluation of meat

Physicochemical and organoleptic analysis of meat was performed 48 h *post mortem*. Meat pH was measured with a penetrating electrode (Hanna Instruments FC232D) connected to a pH meter (Hanna Instruments HI 99163) after calibration with two buffers (pH 4.01 and pH 7.01). The pH-meter automatically corrected pH values, taking into account muscle temperature. Meat colour was determined using the model CR-310 Minolta chroma meter fitted with a 50 mm orifice (Boccard et al. 1981) according to CIE-L*a*b* system. The samples of meat were freshly cut into 3-cm thick steaks and were evaluated after 30 min of bloom time. Heating loss was determined on 1.5-cm thick steaks in an electric cooker at 165°C to an internal temperature of 70°C according to Boccard et al. (1981).

The maximum shear force (F_{max} expressed in N) was measured with a Warner–Bratzler V-blade on texture analyzer Model TA-XT2 plus (Stable Micro Systems, Godalming, Surrey, England). Meat samples were cut (1.5 mm/s crosshead speed) into 10-mm^2 cubes (minimum of 5 per sample) parallel to muscle fibre orientation. Results of shear force measurements were analysed using testXpert II software.

Sensory evaluation (i.e. colour, aroma, flavor, texture, juiciness and delicacy) following heat treatment (roasting) was performed on a 5-point scale (1 point – the worst, 5 points – the best) according to the procedures described by Baryłko-Pikielna and Matuszewska (2014). The organoleptic evaluation was performed by a panel of 9 trained judges.

Statistical analysis

The data obtained during the study were statistically analysed with Statistica ver. 9.1 (2009) using Student's t-test for independent samples.

RESULTS AND DISSCUSION

Chemical composition of meat

Breed had no effect (P >0.05) on basic meat composition (Table 1). As reported by Geay et al. (2001), the chemical composition of muscles is relatively constant, especially for dry matter or protein. The content and composition of lipids stored in muscle depends on genotype, type of ration, its energy, digestion, intestinal absorption, hepatic metabolism and lipid transport systems to muscle (Geay et al. 2001). The meat of ZR bulls was charac-

TABLE 1. Chemical composition of *musculus longissimus lumborum* from Polish Red-and-White (ZR) and Simmental (SM) bulls ($\bar{x}$ ±SD)

Item	Breed	
	ZR	SM
Moisture (%)	75.3 ±0.98	75.81 ±1.00
Crude protein (%)	22.10 ±1.16	22.38 ±0.23
Crude ash (%)	1.07 ±0.03	1.09 ±0.02
Crude fat (%)	1.99 ±0.48	1.50 ±0.64
Cholesterol (mg/g)	0.52 ±0.02	0.51 ±0.05
Vitamin E (µg/g)	2.51 ±0.70	2.04 ±0.57

terized by a higher fat content compared to the meat of SM bulls (1.99 vs 1.5%), but the differences were not significant. Genotype was found to have no effect on the level of vitamin E and cholesterol in the meat. Regardless of the breed, the meat of bulls was characterized by a relatively high vitamin E content (more than 2 μg/g) and low cholesterol content (0.51–0.52 mg/g). Węglarz et al. (2000) found the meat of Red-and-White Lowland and Simmental bulls to have a higher cholesterol content (0.575 and 0.597 mg/g, respectively).

Fatty acid profile

Our study found no effect of breed on the fatty acid profile of MLL fat except for the saturated fatty acids myristic (C14) and palmitic (C16), the proportion of which was higher in the fat of Polish Red-and-White bulls (Table 2, $P \leq 0.05$). Studies conducted to date on the relationship between fatty acid profile of intramuscular fat and genotype allow a conclusion that genotype-related variation in fatty acids is more noticeable in saturated (SFA) and monounsaturated fatty acids (MUFA) than in polyunsaturated fatty acids (PUFA) (Scollan et al. 2006, 2014). Laborde et al. (2001) found Simmental cattle to be characterized by higher activity of Δ-9 desaturase that converts vaccenic acid (C18:1, n-7) to CLA as well as by higher MUFA content. Fat from SM bulls had a higher content of polyunsaturated fatty acids (PUFA), in particular n-6 fatty acids, but the differences were not significant ($P > 0.05$) (Table 2). Enser et al. (1998) report that in ruminants, polyunsaturated fatty acids are preferentially deposited in phospholipids and for this reason less fatty

TABLE 2. Fatty acid composition (% total acid) of intramuscular fat of *musculus longissimus lumborum* from Polish Red-and-White (ZR) and Simmental (SM) bulls ($\bar{x} \pm SD$)

Item	Breed	
	ZR	SM
C10:0	0.03 ±0.01	0.05 ±0.01
C12:0	0.17 ±0.02	0.18 ±0.04
C14:0	1.97 ±0.22[a]	1.22 ±0.34[b]
C16:0	25.03 ±2.56[a]	17.59 ±3.12[b]
C16:1	2.28 ±0.25	1.77 ±0.14
C18:0	21.03 ±1.96	22.09 ±2.48
C18:1	33.16 ±2.8	30.83 ±3.71
C18:2, n-6	8.90 ±1.25	13.06 ±2.28
C20:0	0.12 ±0.03[a]	0.21 ±0.05[b]
C20:4, n-6	4.44 ±1.12	9.27 ±2.56
C18:3, n-3	1.80 ±0.17	2.05 ±0.2
CLA	0.27 ±0.08	0.32 ±0.09
CLA c9-t11	0.20 ±0.02	0.29 ±0.04
CLA c9-c11	0.05 ±0.00	0.00 ±0.00
CLA t9-t11	0.02 ±0.00	0.03 ±0.01
C22:0	0.30 ±0.02	0.41 ±0.04
C22:1	0.01 ± 0.00	0.02 ±0.00
C20:5, EPA, n-3	0.47 ±0.08	0.93 ±0.1
C22:6, DHA, n-3	0.02 ±0.00	0.00 ±0.00
SFA	48.64 ±4.78	41.76 ±4.02
UFA	51.40 ±5.06	58.24 ±4.45
MUFA	35.46 ±2.23	32.62 ±4.12
PUFA	15.90 ±3.89	25.63 ±4.16
PUFA, n-6	13.34 ±3.39	22.33 ±4.85
PUFA, n-3	2.29 ±0.35	2.98 ±0.47
PUFA/SFA	0.35 ±0.08	0.72 ±0.12
PUFA n-6/n-3	5.83 ±1.96	7.49 ±2.32
AI*	0.67 ±0.15[a]	0.41 ±0.13[b]

* Atherogenic index (C12:0 + 4 × C14:0 + C16:0) / / (MUFA + PUFA).

a, b – values in rows with different letters are significantly different at $P \leq 0.05$.

breeds are generally characterized by a higher proportion of PUFA. The atherogenic index was higher in meat from the Polish Red-and-White compared to the Simmental breed (0.67 vs 0.41), which was due to the higher content of saturated fatty acids C12, C14, C16 and the notably lower proportion of PUFA. The atherogenic index alone could suggest that intramuscular fat from the meat of ZR bulls has lower health-promoting value, but of equal importance to the consumers is the n-6 to n-3 ratio, which was lower (more favorable) for the ZR breed (5.83 vs 7.49). As recommended by ISSFAL (2004), it is desirable that the human diet should include fat with low atherogenic index and a low n-6 to n-3 fatty acids ratio (2 : 1).

Physicochemical and organoleptic characteristics of meat

Meat from Polish Red-and-White bulls was characterized by lower shear force ($P \leq 0.05$), greater juiciness ($P \leq 0.01$), more delicate texture ($P \leq 0.05$), and better overall score ($P \leq 0.05$) (Table 3). However, the meat pH_{48h} *post mortem* was relatively high for both ZR and SM breeds, but still around recommended range for good quality of meat, i.e. between 5.4 and 5.8 (Węglarz 2010). Elevated pH is mainly due to various types of stress to which animals are exposed (transport, fasting, temperature). Węglarz (2010) found that only 12% of meat from young bulls slaughtered in the summer season had normal pH values of 5.4–5.8, 30% of meat exceeded 6.2, and more than half exhibited intermediate values. Cattle show the signs of physiological stress when temperatures are slightly over 20°C (Davis and Mader 2001).

TABLE 3. Physicochemical and organoleptic characteristics of *musculus longissimus lumborum* from Polish Red-and-White (ZR) and Simmental (SM) bulls ($\bar{x}$ ±SD)

Item	ZR	SM
Heating loss (%)	35.08 ±4.13	38.13 ±4.20
pH_{48h}	5.86 ±0.19	5.84 ±0.05
Colour		
L	33.44 ±1.17	34.13 ±1.18
a*	19.71 ±0.98	20.02 ±0.73
b*	5.40 ±0.74	5.24 ±1.11
C*	20.44 ±1.04	20.71 ±0.88
Shear force (N)	99.33 ±37.08^{a}	123.07 ±18.5^{b}
Colour	4.67 ±0.10	4.14 ±0.43
Aroma – intensity	3.57 ±0.05	3.69 ±0.12
Aroma – desirability	4.29 ±0.09^{a}	3.96 ±0.17^{b}
Flavour – intensity	3.77 ±0.19	3.52 ±0.23
Flavour – desirability	3.79 ±0.09	3.52 ±0.21
Texture – tenderness	2.55 ±0.14	2.65 ±0.02
Juiciness	3.76 ±0.14^{A}	3.10 ±0.16^{B}
Delicacy	2.90 ±0.23^{a}	2.73 ±0.06^{b}
Overall score	3.65 ±0.03^{a}	3.41 ±0.12^{b}

L* – colour lightness, a* – redness, b* – yellowness, C* – colour intensity.

a, b – values in rows with different letters are significantly different at $P \leq 0.05$, A, B – values in rows with different letters are significantly different at $P \leq 0.01$.

In our study, bulls were slaughtered in the summer season when temperatures exceeded 25°C, which could affect the pH values.

Simmental meat was characterized by higher shear force compared to meat

from the Polish Red-and-White breed ($P \leq 0.05$). It is in line with the study of Litwińczuk et al. (2014b) who reported higher shear force value (no statistical differences) for Simmental meat (97.7 N) than for meat of native breed: Polish Red (92.2 N), Polish Black-and-White (89.0 N). Significant differences ($P \geq 0.05$) were obtained between meat of White-backed cattle (108.9 N) and Polish Holstein (84.9 N). Sochor et al. (2005), comparing the Simmental breed (SM) with Charolais (CH), Czech Pied (CP) and Blonde d'Aquitaine (BA) obtained for this breed high shear force values which were similar to those obtained in our study (SM 110.98 N; CH 86.63 N; CP 84.58 N; BA 119.95 N). Between-breed differences in meat tenderness, due to various course of meat protein degradation, were observed by Iwanowska et al. (2010). The relatively high shear force value (more than 110 N on average), observed in the experiment in comparison with the findings of other authors, results from the difference in the age of animals. The increased toughness of meat with age is strictly associated with the changes occurring in the connective tissue and myofibrils, which become more compact and resistant to the influence of physicochemical factors, including temperature.

Meat colour depends on the concentration and chemical form of myoglobin, the main heme pigment. No significant differences were found in the colour of meat from the breeds under comparison. The results obtained for colour lightness are lower than those reported for the Italian Maremmana bulls slaughtered at both 18 and 24 months of age (Sargentini et al. 2010 – 33.79 vs 38.4 and 41.1 on average). The dark meat colour could also result from the relatively high acidity of the meat.

The organoleptic traits are already observed to improve when the intramuscular fat content ranges between 3.5 and 5% (Mandell et al. 1997). In our study, the intramuscular fat content was not that high, but tests of the organoleptic properties showed that the meat of Polish Red-and-White bulls was more delicate, juicy and had more desirable aroma compared to the meat of Simmental bulls.

CONCLUSION

The Polish Red-and-White and Simmental bulls did not differ in basic chemical composition of the meat, although the conservation breed bulls had a slightly higher content of intramuscular fat. Differences between the breeds occurred for the fatty acid profile of intramuscular fat, but they mostly concerned saturated fatty acids. Meat from Simmental bulls was characterized by lower atherogenic index, while meat from Polish Red-and-White bulls had a lower n-6/n-3 PUFA ratio. The meat of the conservation breed bulls earned higher sensory panel ratings due to its higher juiciness, delicate texture and more desirable aroma.

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Streszczenie: *Porównanie jakości mięsa młodych buhajków ras polskiej czerwono-białej i simentalskiej.* Materiał doświadczalny stanowiło mięso pochodzące od 16 buhajków ras polskiej czerwono-białej (ZR) (n = 8) i simentalskiej (SM) (n = 8). W próbkach mięśnia najdłuższego grzbietu (MLL) oznaczono podstawowy skład chemiczny oraz profil kwasów tłuszczowych tłuszczu śródmięśniowego. Przeprowadzono ocenę fizykochemiczną i organoleptyczną mięsa. W podstawowym składzie chemicznym mięsa nie stwierdzono różnic. W tłuszczu śródmięśniowym ZR stwierdzono wyraźnie mniejszy udział kwasów wielonienasyconych (PUFA), lecz korzystniejszy stosunek kwasów n-6/n-3 w tłuszczu śródmięśniowym MLL. Mięso rasy zachowawczej zostało wyżej ocenione w badaniu sensorycznym z uwagi na większą soczystość, delikatność oraz lepszy zapach.

Słowa kluczowe: bydło, rasa polska czerwono-biała, rasa simentalska, mięso, jakość

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