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COMPARISON OF TEXTURE AND STRUCTURE OF ST (*SEMITENDINOSUS*) MUSCLE OF BLACK-WHITE CATTLE CROSSBREDS WITH CHAROLAISE, MARCHIGIANA, PIEMONTESE AND CHIANINA AND ITS SUSCEPTIBILITY TO MASSAGING

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Changes in texture, structural elements and functional properties of ST (*m.semitendinosus*) of pure breed BW cattle and their crosses with Charolaise (Cha), Marchigiana (Mar), Piemontese (Pie) and Chianina (Chi) beef cattle subjected to massaging were followed.

Of all the groups of animals tested, the most delicate histological structure (the lowest fibre cross-section area, the thinnest perimysium and the highest amount of intramuscular fat), the lowest values of hardness, chewiness, rheological properties and thermal drip and the highest pH were found in ST of BW×Cha and BW which, at the same time, showed the highest value of sensory analyses parameters. The highest values of those parameters were typical of ST of crosses between pure breed BW cattle and an Italian cattle races (Ma, Pie, Chi). Higher values of structural elements, textural parameters, rheological properties and thermal drip loss as well as the lowest pH and the worse sensory analyses showed CB×Chi compared to the other groups of cattle. As demonstrated by data obtained, ST of BW and BW×Cha were the most susceptible to mechanical tenderization. The higher changes in structure, texture and thermal drip losses as well as sensory properties during massaging were recorded in both, BW and BW×Cha groups of cattle. A lower susceptibility to massaging, especially visible in BW×Chi cattle, was caused by cross-breeding between BW pure breed and Italian races.

INTRODUCTION

Beef in Poland originates mostly from cattle of Black-White race determining about 90% stocks of cattle. Opinions regarding qualities of this meat are divided. According to Pisula, [1996] and Wajda & Hutnikiewicz, [1997], Black-White cattle meat was characterized by fair quality and unacceptable tenderness and juiciness as well as excessive marbling and dark colour [Połczyńska & Górska, 1997], while other workers *e.g.* Oryl, [2004], Pogorzelska & Wroński [2005], showed this meat to be poor in fat, tender and tasty.

One of the manners of improvement beef quality is crossing of native races with meat – races [Połczyńska & Górska, 1997; Wajda & Hutnikiewicz, 1997; Nowak & Korzeniowski, 2003].

The French race Charolaise was dominated in crossing till the 90-ies. The Piemontese, Marchigiana and Chianina Italian races appeared on the market from the latter part of the 90-ies [Sakowski & Reklewski, 1996].

One of the reasons of differentiation in structure elements or texture parameters of beef could be the differences between the species [Oryl, 2005, Sobczak *et al.,* 2005], which may have resulted in different susceptibility to massaging [Lachowicz *et al*., 2003 ab; Pietrasik & Shand 2004].

The study presented here was aimed at comparing massaged and non-massaged ST (*m. semitendinosus*) muscle of pure breed White-Black (BW) cow crosses with Charolaise, Marchigiana, Piemontese and Chianina bulls in terms of their texture and structure.

MATERIALS AND METHODS

The study involved meat from young bulls of White-Black dairy cattle race (BW) and their crosses with beef cattle of following genotypes: French race Charolaise (BW×Cha) and an Italian races Marchigiana (BW×Mar), Piemontese (BW×Pie) and Chianina (BW×Chi).

A total of 30 carcasses from cattle of five different genotypes (six carcasses in each group), were used. Animals were slaughtered at the weight of 450±5 kg (their age was 20 months), kept at the cold room for 24 h, and transported to the MasAR Food Industry and Experimental Production Plant, Agricultural University of Szczecin. Hindquarters of carcass served to obtain ST (*m. semitendinosus*) muscle.

Each muscle was cut perpendicularly to the fibres into two parts. Subsequently, samples of 1×1×1 cm for additional structural analyses were cut from the mid-part of the muscle.

One part of each muscle, after weighing, was placed in polyethylene bags, and cooked in water at 75±1°C until the geometric centre of a sample was heated to 68°C. After removal of thermal drip, the cooked samples were cooled at

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4°C in opened bags to about 18±2°C, re-weighed, and stored at cold room for about 12 h until the assays were made.

The second part of each ST muscle was brand with the multicoloured thread, weighed, and injected with curing brine containing 7.8 kg curing salt, 0.9 kg polyphosphate, 0.2 kg sodium ascorbate, and 91.1 kg water per 100 kg of brine, until a 30% weight increase was obtained.

The muscles were massaged intermittently (30 min massaging, 30 min rest) for 8 h in a MP-74 PekMont massaging apparatus, at -0.8 bar vacuum and 8 rpm drum speed. Samples collected from the massaged meat were weighed, and one sample measuring about 1×1×1 cm was cut out, parallel to the fibres, from the middle part of the massaged muscle. Subsequently, the samples were sealed in a heat-resistant bag, and subjected to cooking as above.

pH measurements. The pH_{24} was measured with a CP--125 pH-meter. The measurement was repeated 3 times on each ST muscle, immediately after preparation.

Structure. Histological assays were made on samples cut from the mid-part of both massaged and non-massaged (control) ST muscles of each groups of animals. The samples were dehydrated in alcohol series, fixed in the Sannomiya solution for 12 h, and embedded in paraffin blocks [Burck, 1975]. The blocks were sectioned transversely into 7–8 μm slices with a microtome Microm HM 310. The sections were placed on slides and contrast-stained with hematoxylin and eosin [Burck, 1975].

The MultiScan computer image analysis software was used to evaluate such structural elements of muscle tissue as fibre cross-section area, perimysium thickness, and amount of intramuscular fat. The latter structural element was counted in promille (‰) on area of muscle tissue section (about 0.25 cm^2). The structural elements were measured in each muscle, on 4 slices; a total of about 300–400 muscle fibre and perimysium thickness/ samples were analysed.

Texture. To objectively evaluate texture, rheological and sensory properties of muscles, 20±1 mm thick slabs were cut off from each group of cattle. The texture was evaluated using the TPA (double penetration) test with a computer-interfaced Instron 1140. The test involved driving a 0.61 cm diameter shaft twice into a 20±1 mm high sample down to 70% of its height (14 mm). The force-deformation curve obtained served to calculate meat hardness, cohesiveness and chewiness [Bourne, 1982]. The procedure was repeated 6 times on each sample batch.

Rhelogical properties. Rheological properties were determined with the relaxation test. A sample was compressed to 10% of its original height (2 mm) and left for 180 s. Time-dependent changes in stresses were recorded by the computer every second during the first 15 s, and at 15 s intervals thereafter [Lachowicz, 1992].

The calculate the elastic and viscous moduli, the general Maxwell's body model was used, the model involving a parallel coupling of a Hookes body and two Maxwell's bodies. The following relaxation equation was applied [Lachowicz, 1992]:

$$\sigma=\varepsilon\cdot\left[E_0+E_1\cdot\exp\left(\frac{-E_1\cdot t}{\mu_1}\right)+E_2\cdot\exp\left(\frac{-E_2\cdot t}{\mu_2}\right)\right]$$

where: σ, stress; ε, strain; E_0, E_1, E_2, elasticity moduli of Hook's body and of the first and second Maxwell's bodies, respectively; μ_1, μ_2, viscosity moduli of the first and second Maxwell's bodies, respectively; t, time.

Calculated values of the three elastic moduli are summarised in the figures as their sum; similarly, the values of the two viscous moduli are presented as their sum.

The sensory texture evaluation. The sensory evaluation of texture of beef samples was assessed by a trained expert panel of 5 members. The meat hardness, chewiness and texture desirables were assessed using a 5-points scale as a follows: hardness: 1 – the most tender, 5 – the toughest; chewiness: 1 – very easy to chew, 5 – very difficult to chew; and texture desirability: 1 – the most undesirable, 5 – the most desirable.

Thermal drip. Thermal drip loss (%), in both, massaged and non-massaged muscles, was calculated from the difference in weight before and after the thermal treatment.

RESULTS AND DISCUSSION

The effects of cross-breeding on texture parameters were different and depended on cattle genotype tested (Table 1). Cross-breed between Black-White (BW) and Charolaise (Cha) French cattle caused a decrease (by about 24–11%) in hardness and chewiness. The lowest and insignificant changes in hardness and chewiness were found in BW×Marchigiana (Mar), an Italian race, cross-breed. Whereas, the differences in texture between the toughest and the most difficult to chew ST muscle of BW and an Italian Chianina (Chi) cattle were by about 70–80%. Cross-breeding caused an increase in meat cohesiveness (Table 1), however no significant differ-

TABLE 1. Mean values of texture parameters of ST muscle according to cattle genotype.

Cattle genotype	Hardness (N)		Cohesiveness (-)		Chewiness (N×cm)	
	non-massaged	massaged	non-massaged	massaged	non-massaged	massaged
BW	40.2 ± 3.6^a_1	25.9 ± 2.3^a_2	0.578 ± 0.012^a_1	0.601 ± 0.013^a_1	32.4 ± 3.27^a_1	21.8 ± 2.45^a_2
BW×Charolaise	30.5 ± 3.7^b_1	19.0 ± 2.1^b_2	0.678 ± 0.019^b_1	0.715 ± 0.02^b_2	28.9 ± 3.62^a_1	16.3 ± 1.97^a_2
BW×Marchigiana	46.8 ± 3.4^a_1	33.3 ± 3.4^c_2	0.621 ± 0.010^c_1	0.643 ± 0.012^c_2	40.6 ± 4.25^b_1	29.5 ± 3.23^b_2
BW×Piemontese	59.3 ± 3.1^c_1	47.1 ± 4.6^d_2	0.615 ± 0.009^c_1	0.626 ± 0.011^c_1	52.5 ± 6.31^c_1	41.3 ± 4.07^c_2
BW×Chianina	68.7 ± 4.9^d_1	60.1 ± 6.3^e_1	0.638 ± 0.014^c_1	0.642 ± 0.013^c_1	60.2 ± 3.24^d_1	53.3 ± 5.39^d_1

1, 2 – values in a rows, denoted by different numerals, were significantly different within a breed ($p\leq0.05$); a, b – values in a columns, denoted by different letters, were significantly different between breeds ($p\leq0.05$)

ences were found between BW cattle and their crosses with Italian races.

The textural parameters of the ST muscles were also evidenced by the rheological properties of cross-breeds tested (Table 2). Also in this cases, was the decrease in viscous and elastic moduli caused by cross-breeding between BW with Cha found insignificant, whereas significantly higher values of this parameters were reported in the other crossbreds tested, compared to BW cattle.

The sensory analysis of meat tested showed BW×Chi and BW×Pie ST muscles to be characterised by the highest hardness and difficulty to chew (Table 3) as well as the lowest texture desirability, compared to BW cattle. No significant differences were found between sensory properties of BW and BW×Cha, BW×Mar crossbreds meat.

The histological analysis of ST muscle of pure breed BW cattle and their crossbreds (Table 4) showed no significant differences in mean fibre cross sectional area, perimysium thickness as well as intramuscular fat content between BW and BW×Cha cattle.

A comparison of values of muscle structure elements in the groups of animals tested showed the BW and BW×Cha cattle muscles to have consisted of fibres of a lower cross-section areas, and of higher amount of fat. The highest mean cross sectional area and the thickest perimysium were typical of BW×Chi cattle. Their muscles, similarly to BW×Pie, had less amounts of intramuscular fat (Table 4).

Table 5 presents the values of pH_{24} and thermal drip of cattle ST muscles according to genotype. The highest value of pH was typical of BW meat, the lowest values being recorded both in BW×Chi and BW×Pie ST muscles. The latter muscles were characterised by the significantly higher thermal drip losses, compared to the corresponding muscle of BW cattle.

To sum up that part of research, it can be concluded that cross-breeding between pure-breed BW cattle and an Italian Marchigiana, Piemontese and Chiania races, does not improve the sensory and objectively measured textural properties of meat; even the same increase in muscle hardness and chewiness as well as deterioration of sensory attributes of meat were found, compared to BW pure-breed cattle. It was especially recorded in BW×Chi meat. However, no sig-

TABLE 2. Rheological properties of ST muscle according to cattle genotype.

Cattle genotype	Sum of elastic moduli (kPa)		Sum of viscous moduli (kPa×s)	
	non-massaged	massaged	non-massaged	massaged
BW	$97.2\pm10.2^{a}_{1}$	$112.6\pm9.4^{a}_{1}$	$20318\pm3562^{a}_{1}$	$17650\pm2610^{a}_{1}$
BW×Charolaise	$84.4\pm8.8^{a}_{1}$	$101.8\pm10.5^{a}_{1}$	$16632\pm2198^{a}_{1}$	$14233\pm1366^{a}_{1}$
BW×Marchigiana	$133.1\pm12.8^{b}_{1}$	$147.8\pm13.7^{b}_{1}$	$29393\pm4111^{b}_{1}$	$22450\pm3250^{ab}_{1}$
BW×Piemontese	$247.2\pm25.1^{c}_{1}$	$270.6\pm25.4^{c}_{1}$	$57798\pm8975^{c}_{1}$	$50620\pm6448^{c}_{1}$
BW×Chianina	$316.8\pm30.2^{d}_{1}$	$345.3\pm31.9^{d}_{1}$	$79948\pm10513^{d}_{1}$	$69834\pm7243^{d}_{1}$

1, 2 – values in a rows, denoted by different numerals, were significantly different within a breed (p≤0.05); a, b – values in a columns, denoted by different letters, were significantly different between breeds (p≤0.05)

TABLE 3. Sensory properties of ST muscle according to cattle genotype.

Cattle genotype	Hardness (pt)		Chewiness (pt)		Texture desirability (pt)	
	non-massaged	massaged	non-massaged	massaged	non-massaged	massaged
BW	$2.4\pm0.5^{a}_{1}$	$2.0\pm0.5^{a}_{1}$	$3.7\pm0.3^{a}_{1}$	$3.0\pm0.3^{a}_{1}$	$3.9\pm0.5^{a}_{1}$	$4.4\pm0.5^{a}_{1}$
BW×Charolaise	$3.0\pm0.3^{a}_{1}$	$1.7\pm0.4^{a}_{2}$	$3.3\pm0.5^{ab}_{1}$	$2.5\pm0.5^{a}_{1}$	$4.1\pm0.3^{a}_{1}$	$4.6\pm0.5^{a}_{1}$
BW×Marchigiana	$3.3\pm0.3^{a}_{1}$	$1.3\pm0.5^{a}_{2}$	$3.5\pm0.3^{ab}_{1}$	$3.4\pm0.4^{ab}_{1}$	$3.6\pm0.4^{a}_{1}$	$4.0\pm0.3^{a}_{1}$
BW×Piemontese	$3.9\pm0.5^{b}_{1}$	$3.0\pm0.2^{b}_{2}$	$4.2\pm0.5^{b}_{1}$	$4.0\pm0.5^{b}_{1}$	$2.7\pm0.2^{b}_{1}$	$3.4\pm0.5^{b}_{1}$
BW×Chianina	$4.1\pm0.3^{b}_{1}$	$4.0\pm0.2^{c}_{1}$	$4.5\pm0.6^{b}_{1}$	$4.3\pm0.3^{b}_{1}$	$2.0\pm0.6^{b}_{1}$	$2.6\pm0.4^{c}_{1}$

1, 2 – values in a rows, denoted by different numerals, were significantly different within a breed (p≤0.05); a, b – values in a columns, denoted by different letters, were significantly different between breeds (p≤0.05)

TABLE 4. Mean values of structural elements of ST muscle according to cattle genotype.

Cattle genotype	Fat (‰)	Muscle fibre cross-section area (μm^2)		Perimysium thickness (μm)	
	non-massaged	non-massaged	massaged	non-massaged	massaged
BW	13.4^{a}	$805.3\pm50.4^{a}_{1}$	$1006\pm62.3^{a}_{2}$	$20.27\pm1.22^{a}_{1}$	$21.28\pm1.02^{a}_{1}$
BW×Charolaise	12.9^{a}	$789.9\pm77.1^{a}_{1}$	$1008\pm54.8^{c}_{2}$	$19.89\pm0.78^{a}_{1}$	$21.22\pm1.36^{a}_{1}$
BW×Marchigiana	11.2^{a}	$989.8\pm82.4^{b}_{1}$	$1198\pm69.2^{b}_{2}$	$23.31\pm1.12^{b}_{1}$	$23.90\pm2.21^{a}_{1}$
BW×Piemontese	6.3^{b}	$1190\pm92.6^{b}_{1}$	$1392\pm82.4^{c}_{2}$	$25.22\pm1.61^{b}_{1}$	$25.80\pm1.43^{b}_{1}$
BW×Chianina	7.8^{b}	$1453\pm97.6^{c}_{1}$	$1598\pm100.8^{d}_{1}$	$29.63\pm2.03^{c}_{1}$	$30.40\pm1.94^{c}_{1}$

1, 2 – values in a rows, denoted by different numerals, were significantly different within a breed (p≤0.05); a, b – values in a columns, denoted by different letters, were significantly different between breeds (p≤0.05)

TABLE 5. The pH_{24} and thermal drip of ST muscle according to cattle genotype.

Cattle genotype	pH_{24}		Thermal drip (%)	
	non-massaged	massaged	non-massaged	massaged
BW	$6.01\pm0.19^{a}_{1}$	$6.21\pm0.21^{a}_{1}$	$22.8\pm2.96^{a}_{1}$	$19.2\pm1.24^{a}_{1}$
BW×Charolaise	$5.93\pm0.24^{ab}_{1}$	$6.17\pm0.27^{a}_{1}$	$22.1\pm2.38^{ab}_{1}$	$18.3\pm1.63^{a}_{1}$
BW×Marchigiana	$5.8\pm0.23^{ab}_{1}$	$6.09\pm0.22^{a}_{1}$	$25.1\pm4.46^{ab}_{1}$	$20.4\pm1.76^{a}_{1}$
BW×Piemontese	$5.69\pm0.22^{ab}_{1}$	$6.01\pm0.25^{a}_{1}$	$29.2\pm3.80^{bc}_{1}$	$24.6\pm1.43^{b}_{1}$
BW×Chianina	$5.64\pm0.17^{b}_{1}$	$5.98\pm0.23^{a}_{1}$	$33.9\pm3.60^{c}_{1}$	$28.9\pm2.08^{c}_{1}$

1, 2 – values in a rows, denoted by different numerals, were significantly different within a breed ($p\leq0.05$); a, b – values in a columns, denoted by different letters, were significantly different between breeds ($p\leq0.05$)

nificant differences were found in BW×Mar meat. No significant differences between the intensity of sensory properties of meat of crossbreds between BW and an Italian races were either found by Matuszewska *et al*. [1994], however they mentioned that better meat quality was typical of pure breed BW cattle.

As shown in this work, some increase in muscle tenderness as well as a decrease in chewiness, springiness and viscosity of crossbred between BW and Charolaise were observed (Table 1, 2). The positive effects of Charolaise cross-breeding on meat tenderness were also reported by Wheeler *et al.* [1996] and Sobczak *et al.* [2005], who demonstrated higher tenderness of meat of that cattle, compared to both other races or crossbreds.

As observed in this study, cross-breeding between pure-breed BW cattle and Italian races caused a worse meat structure. The consequences included higher mean fibre cross sectional area, thicker perimysium, and the lower amount of intramuscular fat. Cross-breeding between BW and Charolaise did not affect meat structure deterioration, thus no significant differences were observed in its structure (Table 4).

The data presented in this work allow concluding that a muscle's texture and rheological properties differentiation depended on structural elements of crossbreds meat. A lower amount of intramuscular fat, thicker perimysium and higher fibre cross sectional area were found in crossbreds of BW and Italian races, which at the same time showed the highest hardness, chewiness, elasticity and viscosity as well as lower values of texture desirability, compared with pure breed BW cattle.

No significant differences in the structure between BW and BW×Cha affected a lack of significant differences in meat texture. Numerous authors [Lepetit & Culioli, 1994; Kołczak, 2000; Lachowicz *et al.,* 2003ab] found muscle of higher fibre diameter to be characterised by higher hardness and springiness. Similar to our findings texture-structure relationships were observed also by Wegner *et al.* [2000] and Oryl [2004], who showed lower fibre diameter as well as lower tenderness being typical of dairy cattle. As pointed out by Wheeler *et al.* [1996] higher hardness of Piemontese cattle meat, compared to Charolaise cattle is connected with a higher amount of intramuscular fat in the latter. It could have been connected with a lower hardness of both BW and BW×Cha meat, compared to the other races tested. On the other hand, the higher hardness and chewiness of Italian breeds muscles can result in thicker perimysium, compared to the other groups of animals, which has been corroborated by Kołczak *et al.* [1992] and Brooks & Savell, [2004] who observed muscles with thicker perimysium to have a higher hardness.

Regardless of the samples tested, massaging resulted in a reduction of hardness and chewiness as well as an increase in cohesiveness of all the muscles massaged, compared to the non-massaged controls (Table 1). Texture parameters changes as well as a decrease in thermal drip losses (Table 5) are caused by loosening of and damaging meat structure [Lachowicz *et al.,* 2003b; Pietrasik & Shand, 2005] and protein extraction into intercellular spaces and to the outside [Motycka & Bechtel, 1988].

Changes in the textural parameters tested were dependent on cattle genotype. As observed in this work, the initially tender meat, required less intensive massaging to attain a significant decrease in the textural parameters tested. For example, after massaging hardness and chewiness of the most tender BW and BW×Cha meat decreased by about 36–40%, relative to the control, whereas that of a bit tougher BW×Mar meat by about 28–30%, and that of the toughest BW×Pie and BW×Chia meat by about 20 and 11%, respectively (Table 1). Similarly to our research Boles & Shand [2001], showed that tenderness of massaged meat is connected with the initial meat hardness, while Lachowicz *et al.* [2003a] are of the opinion that it was most likely related to the structure.

Probably, by way of intensive protein extraction, massaging causes an increase in cohesiveness [Shackelford *et al.,* 1989]. Whereas according to Pietrasik & Shand [2004] the decrease in meat cohesiveness during massaging results from excessive structural damage caused by over-massaging, and prior tenderization. On the other hand, Wheeler *et al.* [1990] are of the opinion that mechanical interaction during massaging has no sense for meat with initially not acceptable tenderness.

As shown in this work, massaging caused an insignificant increase in elasticity moduli and decrease in viscous moduli at the same time (Table 2). The intensity of changes was determined by cattle crossbreds and similar to texture changes (Table 1, 2). The highest decrease in rheological properties was found in both the most elastic and viscous meat of BW and BW×Cha cattle, by about 20 and 9%, respectively, compared to the most tough BW×Chi.

An increase in the values of rheological properties during massaging may be difficult to clarify. Probably, an increase in elastic moduli of meat during massaging is connected with an increase in brine sorption by muscle fibre as well as protein binding, and as a consequence "spatial system water-protein" has been done in intercellular spaces, which may cause an increase in meat elasticity during thermal processing.

The sensory properties of the muscles subjected to massaging (Table 3) were evidenced also by data obtained by objective methods differences. Regardless of crossbreds tested, the lowest hardness and chewiness were found in massaged samples of muscles, compared to non-massaged (control) muscle. The highest texture desirability were recorded in both BW and BW×Cha meat, the lowest was typical of BW×Chi crossbred meat.

Massaging was found to induce changes in structural elements of the muscle; a significant increase in the fibre cross sectional area and an insignificant increase in the perimysium thickness (Table 4). The increased mean cross-sectional area of muscle fibres is an evidence of theirs membranes damaging and destruction [Pietrasik & Shand, 2004, 2005] and the consequences include an increase in brine sorption and muscle fibres swelling and changing the shape at the same time [Knight *et al.,* 1989; Lachowicz *et al.,* 2003b]. The increase in perimysium thickness may be an indication of a damage and separations of fibrils caused by proteoglycans changes during massaging [Liu *et al.,* 1996].

As seen in this research, cross-breeding affected changes in structural elements to a different extent (Table 4). The greatest structural and at the same time textural changes during massaging were found in both, BW and BW×Cha, in samples with the highest initial tenderness, the smallest fibre cross sectional are and thinnest perimysium. A reduction in fibre area and thickness of connective tissue by about 25% and 5-7%, respectively, was recorded in meat from both groups of animals. Whereas, reduction by about 17 and 10% for fibre area, and by about 0.3% for perimysium thickness was observed in BW×Pie and BW×Chi meat.

Thus differences in the muscle fibres swelling could have been caused by perimysium thickness. The thicker the perimysium, the lower the changes in connective tissue as well as fibre swelling caused by brine sorption reduction [Katsaras & Budras, 1993; Xaragayo *et al.,* 1998; Lachowicz *et al.,* 2003ab].

The different susceptibility of the crossbreds muscles studied to massaging was evidenced also by differences in the amount of thermal drip loss incurred by them (Table 5). The massaged control sample and also BW×Cha meat suffered less cooking loss, the higher thermal drip being typical of BW×Pie and BW×Chi cattle meat. The differences in the amount of thermal loss in the muscles studied could have been caused by different amount and type of collagen in muscles [Boles & Shand, 2001] as well as different brine-binding capacity of muscle fibre proteins [Pietrasik & Shand, 2004].

To sum up, it can be concluded that cross-breeding between pure breed BW dairy cattle and Italian races did not improve both the texture and the meat structure as well as their muscle susceptibility to massaging; especially for crossbreds with Piemontese and Chianina races. Insignificant deterioration in texture, structure as well as susceptibility to massaging was found in the crossbred between BW and Marchigiana, compared to pure-breed BW cattle. Whereas, the most tender, the easiest to chew and at the same time more susceptible to massaging meat was observed in the crossbred between BW and Charolaise cattle.

CONCLUSIONS

1. The lowest hardness and the most delicate structure were found in ST muscle of BW×Cha, compared to pure-breed BW cattle.

2. Compared to other cattle genotype muscles tested, those of BW×Chi showed the highest hardness, chewiness as well as higher mean fibre cross sectional area, and thicker perimysium.

3. Of the Italian races tested, the lowest differences in all the parameters studied were found in BW×Mar, compared to pure-breed BW cattle.

4. A lower susceptibility to massaging, especially visible in BW×Chi cattle, the least in BW×Mar, was caused by cross-breeding between BW pure breed and Italian races.

5. BW×Cha was characterised by similar to pure-breed BW cattle susceptibility to massaging.

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PORÓWNANIE STRUKTURY I TEKSTURY MIĘŚNIA ST KRZYŻÓWEK RASY CZARNO-BIAŁEJ Z RASAMI CHAROLAISE, MARCHIGIANA, PIEMONTESE I CHIANINA ORAZ JEGO PODATNOŚCI NA PROCES MASOWANIA

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Zbadano strukturę, teksturę i właściwości fizykochemiczne oraz zmiany tych wyróżników pod wpływem masowania mięśnia ST (*m.semitendinosus*) pochodzącego od bydła czystorasowego BW oraz czterech krzyżówek tej rasy z rasami mięsnymi Charolaise (Cha), Marchigiana (Ma), Piemontese (Pie) i Chianina (Chi).

Stwierdzono, że spośród badanych grup bydła najbardziej delikatną strukturą (najmniejszymi włóknami mięśniowymi, najcieńszą tkanką łączną i największą ilością tłuszczu śródmięśniowego), najmniejszymi wartościami parametrów tekstury, właściwości reologicznych, ubytków cieplnych i najwyższym pH charakteryzował się mięsień ST krzyżówki BW×Cha oraz czystej rasy BW, uzyskując jednocześnie najwyższe oceny ogólnej pożądalności tekstury (tab. 1–5). W mięśniu ST mieszańców BW i włoskich ras bydła (Ma, Pie, Chi) zaobserwowano większe wartości badanych parametrów, przy czym największymi włóknami mięśniowymi, najgrubszą tkanką łączną, największymi parametrami tekstury, właściwości reologicznych, ubytków oraz najniższym pH i najgorszą ogólną oceną pożądalności tekstury cechowała się grupa BW×Chi (tab. 1–5). Wykazano, że mięsień ST bydła BW i BW×Cha był najbardziej podatny na masowanie. W obu grupach obserwowano większe zmiany w strukturze, teksturze, w wielkości ubytków oraz wyróżnikach oceny sensorycznej mięśni pod wpływem masowania (tab. 1–5). Krzyżowanie rasy BW z włoskimi rasami spowodowało pogorszenie się podatności mięśni na masowanie, było to szczególnie widoczne w grupie BW×Chi.