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PRELIMINARY COMMUNICATION

COLLAGEN PROFILE AND TENDERNESS OF STRIP LOIN AND SILVERSIDE ORIGINATED FROM POLISH HOLSTEIN-FRIESIAN BULLS OF THE BLACK AND WHITE VARIETY

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The aim of the study was to determine and compare the collagen profile of two beef carcass cuts: silverside (*M. semitendinosus*) and strip loin (*M. longissimus lumborum*), originated from Polish Holstein-Friesian bulls of the black and white variety. Silverside showed higher total, acid-soluble, total soluble, and insoluble collagen content than strip loin. Significant differences between silverside and strip loin were noted in their share of water-soluble and acid-soluble collagen (% total collagen, $P<0.05$). The thermal treatment caused cooking losses, which reached 38% in strip loin and 40% in silverside. There were no significant differences in shear force values or organoleptic quality between the cuts, which indicates their similar usefulness as meat for roasting. The content and profile of intramuscular collagen did not influence the organoleptic quality or shear force values of silverside and strip loin.

Keywords: beef, bulls, collagen, thermal treatment

In the skeletal muscles, the connective tissue is present in the form of *epi*-, *peri*-, and *endomysium* and muscle fascia (Purslow, 2014). The connective tissue is composed of three primary proteins: collagen, elastin, and reticulin. Collagen, located in the proteoglycans matrix, is the protein whose proportion in the connective tissue is the highest (Purslow, 2014). In muscle tissue, the average collagen content ranges from 1% to 6% of protein and depends on many factors, such as muscle type and the sex and diet of animals (Purslow, 2005; Dubost et al., 2013). Different muscles obtained from the same carcass have different collagen content and solubility, which is determined by the location of the muscle in a carcass and its activeness during the animal's life (Jeremiah et al., 2003a). In the muscles that worked harder during the animal's life, the collagen content is higher compared to the less active muscles (Jeremiah et al., 2003a). In the carcasses of highly muscled cattle, thin, tightly packed muscle fibres are present, which prevents them from accumulating higher quantities of collagen (Maher et al., 2004). The animal's age mainly causes a decrease in water-soluble collagen percentage and an increase in insoluble collagen (Serra et al., 2008; Schönfeldt & Strydom, 2011).

In Poland, the most popular cattle breed is Holstein-Friesian, which is represented by 90% of livestock (Iwanowska & Pospiech, 2010). Despite the fact that it is a dairy breed,

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increased interest in its slaughter value is noted due to the fact that young bulls show satisfactory daily body mass gain from 0.8 to 1.2 kg and dressing percentage from 55% to 57% (Nogalski et al., 2014; Wajda et al., 2014). Most frequently, Holstein-Friesian cattle are analysed by their dairy purpose. The evaluation of the breed's slaughter value concerns the dressing percentage and the EUROP classification, although there is a lack of information on muscle collagen profile and concentration, and other quality attributes of the meat obtained from the cattle. Thus, the aim of the study was to determine collagen content and solubility in roasted *M. semitendinosus* and *longissimus lumborum*, offered on the market as silverside and strip loin, obtained from young Polish Holstein-Friesian bulls, and to evaluate selected quality attributes of the meat.

1. Materials and methods

The material comprised *M. longissimus lumborum* (LL, strip loin, n=5) and *M. semitendinosus* (ST, silverside, n=5), obtained from Polish Holstein-Friesian bulls at the age of 18 months slaughtered on the same day. The muscles were cut from cooled carcasses 96 h after slaughter. The muscles were subjected to thermal treatment after 5 days of post mortem ageing, in a convection-steam oven (Küppersbusch CPE 110, Küppersbusch Großküchentechnik GmbH, Gelsenkirchen, Germany) at 180 ºC to obtain 80 ºC in the muscle centre. After thermal treatment the muscles were cooled at room temperature (approx. 20 ºC), and then to 3±2 ºC in a refrigerator. After cooling, the muscles were weighted and samples for sensory evaluation (fragments approx. 4 cm long) were cut. Next, the outer crusted surface of the muscles was removed using a knife, and samples for Warner-Bratzler shear force determination were cut (diameter 1.3 cm, 4 cm long, n=5 for each muscle, n=50 in total). Then, the meat, including the earlier cut crusted surface, was ground using a 3 mm size mesh. Cooking loss and Warner-Bratzler shear force (Instron 5965, Instron, Norwood, MA, USA) at 2 mm s^{-1} shear device speed were determined. Sensory evaluation was conducted on 2 mm-thin slices (Ma-Ga S 712p, Bydgoskie Zakłady Maszyn Gastronomicznych, Bydgoszcz, Poland) by six panellists using a 1 to 9 point scale for tenderness (1: very tough; 9: extremely tender), juiciness (1: extremely dry; 9: extremely juicy), taste (1: bland, atypical; 9: intense, typical), aroma (1: very weak, atypical; 9: extremely intense, typical), and overall liking (1: not acceptable; 9: extremely acceptable). Total collagen (Reich, 1970), water-soluble (Hill, 1966) and insoluble (Modzelewska-Kapituła et al., 2015) collagen contents were determined (n=3 for each muscle sample) based on hydroxyproline content (Blomfield & Farrar, 1964). Acid-soluble collagen content was calculated as a difference between total collagen and the sum of water-soluble and insoluble collagen content, while total soluble collagen content was calculated as a sum of water-soluble and acid-soluble collagen contents. The statistical model was composed on the grouping variable, which was muscle (2 levels: LL and ST) and the dependent variables (16 levels: cooking loss, WBSF, total collagen (mg/100 g), water-soluble collagen (mg/100 g, %), acid-soluble collagen (mg/100 g, %), total soluble collagen (mg/100 g, %), insoluble collagen (mg/100 g, %), tenderness, juiciness, taste, aroma, overall liking). The results were subjected either to variance analysis (cooking loss, WBSF, insoluble collagen content and proportion) or the Mann–Whitney U-test (sensory attributes, total, water-soluble, acid-soluble, total soluble collagen content and proportion) at P=0.05 based on the results of Shapiro–Wilk's and Leven's tests (Statistica 10, StatSoft Inc., Tulsa, OK, USA).

2. Results and discussion

The thermal treatment used in the study caused relatively high cooking losses (Table 1), similar for both muscles (P>0.05). Cooking loss depends on many factors, such as thermal treatment method, final internal temperature of the meat, and its chemical composition (Jeremiah et al., 2003b). The cooking loss for LL and ST muscles noted in the present study was similar to that noted by Palka (2003) for ST muscle heated to 80 °C.

Table 1. Warner-Bratzler shear force values, cooking loss, and collagen content in roasted beef

Attribute	Silverside (*M. semitendinosus*)		Strip loin (*longissimus lumborum)*		Significance
	x	SD	x	SD	(P-value)
Cooking loss (%)	39.8	1.62	37.96	2.39	NS
Shear force (N)	80.65	6.53	80.59	8.13	NS
Collagen (mg/100 g)					
Total	1519.3	238.9	1256.6	315.8	0.000
Water soluble	357.0	198.8	424.6	220.8	NS
Acid-soluble	871.0	224.8	575.0	230.7	0.000
Total soluble	1228.0	181.8	999.6	184.5	0.000
Insoluble	266.0	43.6	192.9	50.0	0.000
Collagen (% of total collagen)					
Water-soluble	23.6	13.5	34.1	18.1	0.031
Acid-soluble	57.9	15.3	47.2	20.6	0.033
Total soluble	81.6	10.7	81.3	12.1	NS
Insoluble	17.8	3.2	16.2	5.8	NS

x: mean value; SD: standard deviation; differences significant at the level of P<0.05; NS: no significant differences at P=0.05

Roasted ST and LL muscles did not differ significantly (P>0.05) in WBSF values (Table 1). The results, which indicated a lack of differences between LL and ST muscles in WBSF values, are in agreement with those reported by Domaradzki and co-workers (2013), but fail to support the findings of Zając and co-workers (2011), who noted higher WBSF values for LL than ST muscle. Both muscles showed relatively high WBSF values (approx. 81 N). Lower WBSF values were reported by Palka (2003) for roasted ST steaks (approx. 62 N). On the other hand, Therkildsen and co-workers (2008) reported also high WBSF values for LL muscles obtained from Holstein-Friesian young bulls after 2 days of ageing (approx. 85 N). Results obtained indicate that meat obtained from Polish Holstein-Friesian bulls needs more than 5 days of post mortem ageing to tenderize.

LL muscle showed lower (P<0.05) total, acid-soluble, total soluble, and insoluble collagen contents than ST muscle, whereas ST muscle showed a higher percentage of acid-soluble collagen (% of total) and lower water-soluble collagen (% of total) contents than LL

muscle ($P<0.05$, Table 1). There were no differences between the muscles in terms of insoluble and total soluble collagen percentages. During thermal treatment, collagen fibres are destroyed as a result of the thermal hydrolysis of collagen. Tropocollagen molecules break down mainly into three constituents: α, β, and γ, among which α-constituents are soluble in water and inert salts solutions, while the remaining (β and γ) solubilise in 0.5 M CH_3COOH (Reich, 1970). In the present study, soluble collagen accounted for over 80% of total collagen. This indicates a low degree of collagen cross-linking, which is typical for meat obtained from young animals. The results of this study are in line with those of Zając and co-workers (2011) and Domaradzki and co-workers (2013), who found that ST muscle had higher total collagen content than LL muscle. Kwiatkowska and co-workers (2010) reported a lack of difference between LL and ST muscles in insoluble collagen content, which is in accordance with our findings. The total collagen content noted in the present study was similar to that reported by Domaradzki and co-workers (2013) in LL and ST muscles (1403 mg/100 g and 1936 mg/100 g, respectively), obtained from the carcasses of young Holstein-Friesian Black and White variety bulls. However, the results of the present study concerning total and insoluble collagen content in LL muscle were higher than those reported by Christensen and co-workers (2011) for meat obtained from beef breeds. Average total collagen content in LL muscle was 287 mg/100 g for Limousine and 368 mg/100 g for Charolais; insoluble collagen contents were 215 and 278 mg/100 g, respectively (Christensen et al., 2011).

Roasted LL and ST muscles did not differ in any sensorial attribute ($P>0.05$). The lack of significant differences in sensorial tenderness between LL and St muscles is in agreement with the results of instrumental measurements of tenderness (WBSF). Both muscles were rated relatively high in sensorial assessment (average values for all attributes ranged from 7.9 (ST aroma) to 6.6 (juiciness of LL and ST) in 9 point scale. The good eating quality of meat obtained from young Polish Holstein-Friesian bulls has also been reported by Wajda and co-workers (2014).

Although LL muscle had lower total and insoluble collagen content than ST muscle, it did not produce differences in tenderness between the muscles. However, reports concerning the influence of collagen on meat tenderness are ambiguous. Jeremiah and co-workers (2003b) showed that total and insoluble collagen contents were negatively correlated with sensorial tenderness, while Chriki and co-workers (2013) noted a positive correlation between WBSF values and total and insoluble collagen content. On the other hand, Christensen and co-workers (2011) found that the concentration of particular collagen fractions in LL muscle was not correlated significantly with WBSF values. Dubost and co-workers (2013) reported positive correlations between total collagen and sensorial tenderness, as well as insoluble collagen content and aroma acceptability.

3. Conclusions

Longissimus lumborum and *semitendinosus* muscles obtained from the carcasses of young Polish Holstein-Friesian bulls differed in total collagen and particular collagen fractions. After thermal treatment a higher content of collagen content was found in *semitendinosus* muscle. There were no differences in total soluble and insoluble collagen content between the muscles, which indicates similar degrees of cross-linking in collagen fibres. *Longissimus lumborum* and *semitendinosus* muscles did not differ in terms of cooking loss, shear force, or

eating quality, which indicates their similar usefulness as meat for roasting. Collagen content and solubility of the muscles did not affect their sensorial or instrumental tenderness. The meat from Polish Holstein-Friesian bulls should be subjected to longer than 5 days post mortem ageing to tenderize.

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