Functional and sensory attributes of normal pH values in Sm and Ld of bull muscles depending on time of cutting and aging

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Background- Several researches have examined how excision time (hot and cold boning) and/or aging under various conditions affects physicochemical and biological changes and how this effects tenderness and other quality attributes mainly in beef Ld muscle [1,2,6]. Polish legislation requires that beef parts or cuts be aged no longer than 60 after excision at 24 h p.m. [16]. Except for one research paper [4], that also utilized the Ld muscle, there was not found any comparison of functional properties and quality attributes of muscles cut 24 and 48 h p.m. and given additionally aging.
Objectives- The aim of this work was to examine the influence of aging time up to 96 h p.m. on the functional properties and quality attributes of the bulls semimembranosus (Sm) muscles with normal pH (pH<5.8) cut 24 and 48 h p.m. Also compared was the functional properties and quality attributes of Sm and Ld [11] to investigate if these factors are muscle dependent.

Methods- The Sm muscles was taken from young bulls 24 hours and 48 hours p.m. after commercial slaughter. At different periods, the Sm muscles with a pH<5.8 were excised from six different bulls. The identical procedure was utilized in selection of the Ld muscles. The Sm and Ld muscles were stored at 2-4°C for up to 96 h p.m. Three 2.5 cm thick steaks after each storage day were cut. From the median side of one steak five to eight cores of 2 cm diameter and 1 cm thick were obtained to evaluate the lean colour attributes [18]. The remaining meat was ground. The pH was measured by insertion of electrodes into the ground meat. Water holding capacity (WHC) was expressed as percent of bound water [19]. A meat homogenate was used for determination of viscosity (Pa x s) at a shear rate of Dr 16.2 (s^{-1}) with a Rotatory viscometer "Rheotest-2" with attachment H. The two remaining steaks from each muscle in separate plastic bags were cooked in a water-bath at 80°C for 90 min, cooled for 40 min and weight loss was reported as % cooking loss. Steaks were cut into 6 sections (2 cm^2) for sensory evaluation and into 6-8 slices (3 x 2 x 2 cm length x width x depth) for Warner-Bratzler peak shear force (kg). Samples were evaluated by 6 trained judges based on a 7 point scale for flavour 1-extremely strong; juiciness 1-extremely juicy; firmness 1-extremely weak; and tenderness 1-extremely tender. For each of 6 animals studied multiple determinations were obtained: 5 to 8 for colour/slice, 2 to 3 for functional properties with minced meat, 6-sensory evaluation and 6 to 8-shear force of steaks/slices. Analysis of variance and Duncan's method were used to test differences [13].

Results and discussion - The pH, dominant wavelength, colour purity, cooking losses, firmnes and tenderness for the Sm muscles both cut 24 and 48 h p.m. did not change sig. during aging and were comparable for corresponding storage times (Table 1). WHC for muscles cut 24 h p.m. and after 48 and 96 h p.m. was the highest. For the Sm muscle cut 48 h p.m. WHC sig. increased after 72 h p.m. WHC of Sm muscles cut 48 h p.m. in relation to WHC of Sm muscles cut 24 h p.m. and after 72 h p.m. was sig. higher by 4.57%. The lowest meat homogenate viscosity (MHV) for Sm muscle cut after 24 and 48 h p.m. was found after 72 h p.m. of storage. MHV for Sm muscles cut 24 h p.m. compared with viscosity for Sm muscles cut 48 h p.m. was sig. higher (2.84 to 4.31 times) at the corresponding storage times. Lightness of Sm muscles cut 48 h p.m. increased during aging. After 96 h p.m., the value was sig. higher than after cutting 48 h p.m. Moreover, lightness of the Sm muscles cut 24 h p.m. and after 48 h p.m. was higher by 1.42% than for the Sm muscles after cutting at 48 h p.m. Within each muscle group up to 72 h p.m. when cut 24 h p.m., and up to 96 h p.m. when cut 48 h p.m. there were no sig. differences in sensory attributes except flavour. The flavour intensity of steaks from Sm muscles cut 48 h p.m. decreased and after 96 h p.m. was sig. different than after cutting 48 h p.m. The steaks from Sm muscles after cutting 48 h p.m. were found to have sig. higher flavour intensity than samples from the Sm muscles after cutting 24 h p.m. and after 72 h p.m. Moreover, steaks from the Sm muscles after cutting 48 h p.m. were estimated as being less juicy than steaks from the Sm muscles after cutting 24 h p.m. and after aging for 48 h. p.m. These differences in juiciness evaluation of steaks did not correspond with the WHC and cooking losses values which for corresponding periods were not significantly different. The shear force (SF), which was lower after 48 and 72 h p.m. for steaks from the Sm muscles cut 24 h p.m. than for steaks from the Sm muscles cut 48 h p.m., was not reflected in sensory estimation of the Sm steaks tenderness and firmness. The pH of Sm and Ld muscles both cut 24 and 48 h p.m. for all storage times up to 96 h p.m. is comparable. For corresponding storage times WHC of the Sm muscles cut 24 h p.m. was higher from 2.43 to 4.5% than WHC of the Ld muscles cut 24 h p.m. For the Sm and the Ld muscles cut 48 h p.m. the differences in WHC for the corresponding periods were less than 1.67%. Although differences in WHC between the Sm and the Ld muscles were found, these differences were not reflected in cooking losses for both muscles. The viscosity (MHV) of the Sm muscles both cut 24 and 48 h p.m. after 72 h and 96 h p.m. was lower by 26.33 and 46.03% than the viscosity of the Ld muscles in corresponding times. MHV for Sm and Ld muscles cut 24 h p.m. was sig. higher than muscles cut 48 h p.m. The Sm muscles compared with the Ld muscles during storage had higher dominant wavelength and colour purity and lower (when cut 24 h p.m.) or similar (when cut 48 h p.m.) lightness values. When comparing the sensory attributes of steaks from the Sm and the Ld muscles cut 24 h p.m. and cut 48 h p.m. the results indicated that there was more flavour intensity in steaks from both kinds of muscles cut 48 h p.m. which decreased during storage time. Tenderness in the Ld muscles cut 48 h p.m. resulted in a higher degree of acceptance than in the Sm muscles and what agrees with the SF results. The lack of changes in pH of the Sm and the Ld muscles and the lower lightness of the Sm muscles after cutting 48 h p.m. than after aging up to 96 h p.m. (Table 1) is consistent with results of Spanier et al. [17] and Griffin et al. [7], respectively. According to Eikelenboom and Smulders [4] the Ld bull muscles cut 24 h p.m. with pH 5.74 were sig. darker as compared with the Ld muscles cut from corresponding carcasses after 48 h p.m. with a pH of 5.56. Discrepancy with data for lightness probably results from higher (0.21 units) pH for muscles cut 24 h p.m. in the Eikelenboom and Smulders [4] study. Differences in dominant wavelength and lightness found between each muscles group, can be partly explained by the fiber type composition of the Sm and the Ld which shows that the Sm has sig. more white fibers and less oxidative fibers than did the Ld [8,14] or by differences in metmyoglobin formation in

these muscles [10]. The flavour intensity decrease found in the Sm and the Ld muscles cut 48 h p.m. during storage time (Table 1) is not in agreement with reverse findings of Fjelkner-Modig and Ruderus [5]. Some authors have shown a lack of sig. differences in juiciness [5] and SF [4,5] with steaks from the Sm and/or the Ld of bull muscles cut at different times p.m. and during aging what agreed with these results. The SF values in steaks from the Ld muscles (differently than for the Sm) cut 24 h p.m. decreased after 72 h p.m. This agrees with results of authors who found a reduction in SF in steaks from the Ld muscles [9,15]. Steaks from the Ld muscles after cutting 48 h p.m. had higher SF than steaks from the Sm muscles in this research. In part this could be explained by the fact that the Ld muscles have sig. more oxidative fibers than Sm [14] and therefore oxidative fibers have a more intense sarcomere shortening than glycolytic (white) fibers [3]. Insig. changes in tenderness of the Sm muscles cut both 24 and 48 h p.m. during aging and improvement in tenderness found in the Ld muscles cut 48 h p.m. and after 72 h p.m. are not and are, respectively, in line with Fjelkner-Modig and Ruderus [5] results. The observed higher tenderness changes in the Ld than in the Sm muscles cut 48 h p.m. probably is caused by more rapid degradation of the myofibrillar structure in the Ld than Sm muscles what was recently proved by O'Halloran et al. [12].

Conclusions- Considering higher lightness after 48 h p.m. and lower SF after 48 and 72 h p.m. in the Sm muscles, and higher lightness and lower SF in all storage times for the Ld muscles cut 24 h p.m. than that cut 48 h p.m. it appears that muscles cut 24 h p.m. should be directed toward the retail trade. In further processing, it is necessary to take into account that the highest WHC and/or the lowest SF is obtain for the Sm and the Ld muscles after 48 h p.m. and 96 h p.m., when cut 24 h p.m., and the Sm and the Ld muscles after 72 and 96 h p.m., when cut 48 h p.m. Results revealed considerable differences in functional properties and colour parameters as influenced by muscle type.

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Table 1 Means for functional properties and colour parameters of Sm and Ld muscles cut 24 h p.m. and 48 h p.m. from bulls carcasses and after thermal treatment for shear force and sensory characteristics of steaks during cold aging up 72 or 96 h.

Parameter	Type of muscle	Muscles cut 24 h p.m.		Aging time (h p.m.)		Mucles cut 48 h p.m.		
		24	48	72	96	48	72	96
pH	Sm	5.40	5.45	5.48	5.47	5.45	5.50	5.51
	Ld	5.53	5.52	5.53	5.54	5.54	5.57	5.56
WHC [%]	Sm	5.96^{abc}	8.25^{bcd}	4.25^{a}	7.96^{bcd}	5.30^{ab}	8.82^{cd}	9.49^{d}
	Ld	2.39^{a}	3.75^{ab}	1.82^{a}	3.82^{ab}	5.82^{bc}	10.11^{d}	7.82^{cd}
Viscosity [$Paxs^{-1}$]	Sm	255.88^{ab}	270.27^{a}	223.94^{b}	231.08^{ab}	95.12^{c}	51.60^{d}	62.30^{c}
	Ld	235.60^{a}	295.99^{b}	316.35^{b}	313.95^{b}	89.83^{c}	79.88^{c}	115.52^{c}
Cooking losses [%]	Sm	42.07	42.32	42.50	-	41.95	41.11	41.33
	Ld	38.23	40.48	40.60	-	38.55	39.46	39.87
Domin. wav. [nm]	Sm	635.71	635.52	639.19	636.53	637.88	639.79	637.00
	Ld	627.52^{ab}	628.26^{ab}	625.95^{a}	631.43^{bc}	629.75^{abc}	630.26^{abc}	632.97^{c}
Colour Purity [-]	Sm	0.761	0.756	0.804	0.768	0.784	0.812	0.777
	Ld	0.660^{ab}	0.668^{ab}	0.642^{a}	0.704^{bc}	0.684^{abc}	0.704^{bc}	0.724^{c}
Lightness [%]	Sm	16.14^{ab}	17.04^{a}	16.34^{ab}	16.95^{a}	15.62^{b}	16.16^{ab}	17.50^{a}
	Ld	17.43^{ab}	17.16^{abc}	18.18^{a}	18.18^{a}	15.88^{d}	16.15^{cd}	16.86^{bcd}
Flavour	Sm	3.85^{ab}	3.75^{abc}	4.35^{a}	-	3.14^{c}	3.55^{bc}	4.17^{ab}
	Ld	3.85^{ab}	4.05^{ab}	4.20^{a}	-	2.71^{c}	3.30^{bc}	4.08^{ab}
Juiciness	Sm	4.35^{ac}	3.90^{c}	4.55^{abc}	-	5.36^{b}	4.80^{ab}	4.75^{abc}
	Ld	4.40	4.25	4.00	-	4.63	4.95	4.75
Firmness	Sm	5.72	5.40	5.36	-	5.42	5.38	5.00
	Ld	5.46^{a}	5.32^{a}	4.75^{b}	-	5.67^{a}	5.55^{a}	5.67^{a}
Tenderness	Sm	4.83	4.46	4.05	-	5.14	5.21	4.75
	Ld	4.73^{ab}	4.65^{ab}	4.10^{b}	-	5.36^{a}	5.32^{a}	4.21^{b}
Shear Force [kg]	Sm	9.09^{ab}	8.42^{b}	7.49^{b}	-	10.98^{a}	10.51^{a}	10.78^{a}
	Ld	8.89^{a}	8.70^{a}	6.44^{b}	-	18.97^{c}	11.90^{d}	11.14^{d}

Means with a different superscripts in the same row are significantly different at the 5% level