FUNCTIONAL & SENSORY ATTRIBUTES OF HIGH PH VALUES IN SM AND LD OF BULL MUSCLES DURING STORAGE

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Introduction - Literature points to the relationship between quality of meat and humanitarian handling of animals, appropriate slaughter (electrical stimulation) and carcasses cooling (Strzelecki, 1987/1988; Wichlacz, 1995). A common phenomenon in Polish slaughterhouses is the incidence of DFD (Dark, Firm and Dry) meat which is due to a high, ultimate pH (pH>6.2) caused by alteration in the breakdown of muscle glycogen producing dark-purple color, dry sticky appearance, closed structure, lower values for flavor and palatability, microbial growth and this results in reduced shelf-life for fresh meat (Fjelkner-Modig and Ruderus, 1983; Kowalski, 1983/1984; Wichlacz, 1995). The elevated pH produces higher water holding capacity, reduced cooking shrinkage and better tenderness compared to meat of normal pH (pH <5.8). This can be an advantage in sausage production (Pisula, 1996). This research examined the influence of storage time (up to 96 h) on functional and sensory attributes of the *Semimembranosus* muscle (Sm) of bulls which were DFD. In order to find if type of muscle has an influence on DFD meat the Sm muscles were compared with the previously reported (Lesiów, 1996) *Longissimus dorsi* (Ld).

Experimental - Sm was taken from young bull carcasses 24 hours after slaughter and rapid cooling in a Wroclaw Meat Factory. Muscles were stored at 2-4°C for up to 96 h. Lean color was measured with a Spectrophotometer "Specol" equipped with R 45/0 attachment at 540 and 640 nm (Tyszkiewicz, 1964). The pH was measured with a meter by electrodes insertion into ground meat. Water holding capacity (WHC) was expressed as % of bound water (Wierbicki et al., 1962). A meat homogenate was used for determination of viscosity (Pa x s) at a shear rate Dr 16.2 (s^{-1}) with a Rotatory viscometer "Rheotest-2" with attachment H, and emulsion stability (Lesiów, 1993) expressed as the quantity of oil (ES_o) and water (ES_w) bound by 2g of meat homogenate. Two steaks were cooked in a water-bath at 80°C for 90 min, cooled for 40 min and weight loss was reported as % cooking loss. After refrigeration for 18 hrs the steaks were cut into 6 sections (2 cm) for sensory evaluation and into 6-8 slices (3 x 2 x 2 cm length x width x depth) for the Warner-Bratzler peak shear force (kg). Samples were evaluated by 6 trained judges based on a 7 point hedonic scale for flavor 1-extremely strong, 7-extremely weak; juiciness 1-extremely juicy, 7-extremely dry; firmness 1-extremely weak, (soft), 7-extremely firm; and tenderness 1-extremely tender, 7-extremely tough. Three replicates were evaluated. Analysis of variance and Duncan's method were used to test differences (Oktaba, 1980).

Results and discussion - Sm and Ld muscles at 24 h p.m. which had an ultimate pH higher than 6.2 were treated as DFD meat. The pH of Sm muscles did not change significantly during storage and was lower than the pH of the Ld muscles (Table 1). The pH of Ld muscles after 96 h significantly decreased to a level similar to the Sm muscles. A lack of changes during storage in pH of the Sm muscle caused no change in WHC. The pH decrease in the Ld muscles during storage can explain the decrease in WHC which after 72 h was not significantly different from the Sm muscles. After 24 and 48 h WHC of the Ld was higher than the Sm muscles by 32.01 and 27.02%, respectively. Viscosity of the Sm muscles compared with the Ld muscles was significantly lower for all storage times and ranged from 12.58 to 32.67%. The highest viscosity for both muscles was found after 72 h. Emulsion stability and color purity did not change significantly during storage and were comparable for both muscles. Changes in remaining color parameters were found only for the Sm muscles i.e. the dominant wavelength after 48 h was higher than after 96 h and lightness after 48 h was lower than after 24 and 96 h. The dominant wavelength of the Sm muscles after 48 h was the highest and also significantly higher (5.21nm) than the value for the Ld muscles after 24 h. Similar, but inverse relationships were observed for lightness with the Sm muscles after 48 h being lighter (0.97 to 1.37%) after 24 h, 72 and 96 h than the Ld.

No significance in steaks cooking losses from Sm and Ld muscles were found during storage but Sm steaks had higher (8.01 to 8.21%) losses than Ld steaks. Such a differences could be explained by higher pH of the Ld muscles. Within each muscle group up to 72 h there were no significant differences in sensory attributes. Comparing these attributes between the two muscles one can find that steaks from the Sm muscles were evaluated as having significantly less intensive flavor, less juiciness and tenderness and higher firmness. The sensory estimation of the Sm being less tender than the Ld steaks was not reflected by the shear, which were not significantly different within all examined periods. The less juiciness of the Sm was expected due to the lower WHC (after 24 and 48 h) and higher cooking losses.

Comparing (Lesiów, unpublished data) normal pH with DFD meat was characterized by higher WHC (50.80 to 54.58% for Sm and 56.87 to 86.73% for Ld) lower values of lightness (0.64 to 2.7% for Sm and 2.12 to 2.75% for Ld) and lower cooking losses (5.87 to 6.64% for Sm and 11.01 to 12.39% for Ld). These results are comparable with those of Klupczyński et al. (1985/1986) who found that the Ld muscles with high pH (6.0) had greater WHC, lower lightness and cooking losses than muscles of pH 5.87. At high pH, muscle fibres are more tightly packed as a result of increased WHC and meat surface lightness is lower because it does not scatter light as meat of lower pH (Renerre 1990). Comparing with normal pH (Lesiów,unpublished data) the DFD meat was more tender(shear for SM was lower by 41.09 to 58.48% and for Ld 12.73 to 39.66%). Dransfield (1994) and Ouali (1992) explained that at high ultimate pH calpains are more effective and they act rapidly, and in spite of the fact that inactivation is also rapid the tenderization occurs before 24 h and no further ageing occurs.

Conclusions - Most of the functional and sensory properties of the Sm and Ld muscles of high (pH>6.2) ultimate pH (except for pH and WHC for Ld; dominant wavelength and lightness for Sm; and viscosity for Ld and Sm muscles) did not change during storage up to 96 h. Bull's Sm in comparison with the Ld muscle had lower pH (after 24,48 and 72h), WHC (after 24 and 48h) and viscosity (after 24,48,72 and 96h). Steaks from the Sm versus Ld had higher cooking losses, and less intense flavor, less juiciness and tenderness and higher firmness. DFD meat has a reduced shelf-life so it is preferable to process this meat separately and early.

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Table 1 - Means and standard deviations (sd) for functional and color parameters of 24 h p.m. Sm and Ld bull muscles and after thermal treatment for shear force and sensory characteristics of steaks during refrigerated storage for 72 or 96 h.

Parameter	Storage time (hours post mortem)							
	Sm muscles				Ld muscles			
	24	48	72	96	24	48	72	96
pH	6.31[ab] (0.04)	6.25[b] (0.08)	6.25[b] (0.01)	6.24[b] (0.09)	6.62[c] (0.01)	6.61[c] (0.13)	6.46[a] (0.03)	6.30[b] (0.09)
WHC(%)	57.11[a] (3.33)	59.11[a] (5.31)	58.83[a] (5.77)	58.83[a] (2.60)	89.12[b] (18.80)	86.13[bc] (19.69)	73.88[ac] (4.55)	60.69[a] (10.61)
Viscosity of meat homog. (Pa x s)	158.39[a] (20.78)	217.87[b] (39.73)	260.91[cd] (29.59)	236.34[bc] (14.54)	235.25[bc] (15.25)	289.67[e] (24.42)	298.44[e] (0.00)	281.24[de] (2.73)
Emulsion Stability (ES_o)% of bound oil /2g meat	64.24 (5.07)	63.65 (3.10)	66.84 (4.47)	60.57 (5.59)	61.96 (2.92)	70.31 (2.71)	69.89 (8.57)	65.86 (6.57)
Emulsion Stability (ES_w)% of bound water/2g meat	14.79 (1.52)	14.61 (0.81)	14.85 (0.61)	14.79 (0.54)	14.98 (0.58)	14.66 (0.65)	15.02 (0.51)	14.70 (0.53)
Cooking losses, %	35.43[a] (3.46)	36.45[a] (2.27)	36.22[a] (2.25)	-	27.22[b] (2.06)	28.32[b] (1.72)	28.21[b] (0.75)	-
Dominant wavelength (λ_d) (nm)	624.41[ab] (3.82)	625.89[a] (3.57)	622.56[ab] (3.66)	620.54[b] (3.65)	620.68[b] (3.24)	622.63[ab] (4.47)	622.73[ab] (3.31)	623.18[ab] (4.24)
Color Purity (Pe) (-)	0.625 (0.042)	0.641 (0.040)	0.605 (0.038)	0.585 (0.036)	0.586 (0.033)	0.606 (0.047)	0.606 (0.024)	0.610 (0.044)
Lightness (Y) (%)	15.50[a] (0.93)	14.34[b] (0.92)	14.96[ab] (1.06)	15.54[a] (0.54)	15.31[a] (0.93)	14.98[ab] (0.95)	15.71[a] (0.76)	15.43[a] (1.16)
Flavor	3.73[a] (0.91)	4.27[a] (0.56)	3.75[a] (0.86)	-	2.78[b] (0.75)	3.11[b] (0.86)	2.82[b] (0.73)	-
Juiciness	4.13[a] (0.77)	4.41[a] (0.63)	4.18[a] (0.82)	-	3.27[b] (0.85)	3.22[b] (0.79)	3.24[b] (0.81)	-
Firmness	5.00[ac] (0.39)	5.46[a] (0.52)	5.25[ac] (0.62)	-	4.47[b] (0.67)	4.87[bc] (0.40)	4.83[bc] (0.66)	-
Tenderness	4.25[ac] (0.79)	4.54[a] (0.89)	4.04[a] (0.84)	-	3.18[b] (0.99)	3.65[bc] (0.84)	3.06[b] (0.95)	-
Shear Force (SF)	5.33 (0.48)	4.96 (1.78)	4.87 (1.12)	-	6.51 (1.70)	5.25 (1.89)	5.62 (1.36)	-

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