QUALITY OF CURED AND SMOKED BEEF TENDERISED BY VARIOUS CHEMICAL SUBSTANCES

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Introduction
Tenderness is one of the most important quality parameters of beef (Carmack *et al.*, 1994). Beef tenderness can be modified by different methods such as genetic (Cundiff, 1992), enzymatic (Katsaras *et al.*, 1984), physical (Miller *et al.*, 1998) and chemical (Berge *et al.*, 1998). However, the results of application of some chemical substances for improving beef quality are sometimes controversial mainly due to a negative correlation between tenderness and other quality parameters of beef such as colour, flavour or production yield (Seuss and Martin, 1991). This method is still of interest of meat researchers. The majority of literature data concerns the quality of culinary beef, whilst there is still a lack of knowledge about improving tenderness of beef cuts, which are further used in meat technology. The objective of this study was to create the most suitable chemical method for tenderisation of beef which is to undergo further processing.

Materials and Methods
The study was carried out on round beef muscle *musculus semitendinosus* (pH_{24}<5.75) cut off from 9 carcasses of Polish black and white young bulls of 500 kg average weight.. Each muscle was divided into four parts and randomly assigned as **C** – control muscle cured with standard brine solution; **CC** – muscle injected with brine containing 0.3 M calcium chloride; **LA** – muscle soaked in 1.2% of lactic acid (20 h) before standard curing procedure; **BS** – muscle soaked in 30% of sodium bicarbonate (8 h) before standard curing. Standard curing solution contained curing salt, polyphosphates, sucrose, carrageenan, sodium isoascorbate and monosodium glutamate. Beef samples were injected with brine solution up to the level of 40% and tumbled for 17 h at 4°C. Then, meat from all experimental groups was smoked at 50°C and scalded at 80°C until the temperature at the geometric centre of the product reached 72°C. The products were then chilled at 4°C for 24h.
Reaction (pH) was measured in raw meat 24 h after slaughter as well as in semi-final (after curing) and final products. Sensory analysis especially evaluation of tenderness and overall acceptability was performed by a trained panel using a 6-point hedonic scale (1= not acceptable and 6 = very acceptable). Colour measurements (L*, a*, b* system) were performed using Minolta equipment. Moreover, colour stability (ΔE6, ΔE12, ΔE24) was calculated on the basis of L*, a*, b* data measured respectively after 6 h, 12 h and 24 h (cross-sections of the products were exposed on white fluorescent light with an intensity of 250 lux). Free amine group content was determined according to Kuchroo *et al.*, 1983) and free nitrates(III) content on the basis on the colour reaction of $NaNO_2$ with Griess' reagent. All the results were then statistically analysed using STATISTICA (version 6.0) at a significance level of P=0.05.

Results and Discussion
Reaction (pH) of beef measured 24 h after slaughter was quite consistent and equaled 5.48 average. pH values increased after curing processes by about 0.3 for control sample, 0.4 for beef cured with brine containing $CaCl_2$, and 1.8 for meat treated with $NaHC0_3$. In final products from control and CC groups, pH values were similar (average 6.00) while in **LA** samples it was statistically lower (4.8), resulting in a reduction of sensory acceptance. Final beef products treated with sodium bicarbonate were characterised by high pH (8.05), which consequently diminished the durability of analysed meat products. The highest increase in yield after curing was noticed for beef from **LA** and **BS** experimental groups (33% and 34% respectively). Moreover, those products were characterised by extremely different pH values i.e. 5.24 for LA and 7.28 for **BS**. An increase in free amine group content was the result of protein degradation caused mainly by tenderising substances used in the study. The highest amount of free amine group was found in the most tender beef products from **LA** and **BS** blocks (Figure 1); 7853 μg Gly/g protein and 7640 μg Gly/g protein, respectively. Moreover, beef treated with brine containing sodium bicarbonate or lactic acid were distinguished by extremely different sensory properties, especially in overall acceptability, colour and flavour (Table 2, Figure 2). Lower sensory scores obtained for LA beef arose fom large variations in colour. There was a darker layer, about 1 cm wide, which was clearly seen on the circumference of the cross-section of the final product. Moreover, products made from beef previously cured with brine containing lactic acid had a slightly acidic taste. Beef treated with **LA** or **BS** were characterised by lower values of L* than the control group, while $CaCl_2$ solution used as a tenderising agent lightened the products. The participation of red colour (a*) in the whole hue spectrum of the control beef was comparable with products from the **BS** group and higher than measured for **CC** and **LA** products. However, beef cured with brine containing **LA** and **BS** was characterised by lower participation of yellow colour (b*) in the spectrum than the beef analysed for **C** and **CC** groups. Moreover, the colour of beef treated with **BS** was the most stable, which was explained by low values of Δ6, Δ12 and Δ24 (Table 1). Free nitrite(III) content in final experimental beef products was not effected by tenderising agent used. The highest

amount (but still considered to be safe) of free nitrite (92.38 ppm) was found in beef cured with sodium bicarbonate. The final products from this experimental block were also characterised by the most acceptable sensory and physicochemical properties.

Conclusion

From technological, physicochemical and sensory points of view, sodium bicarbonate emerged as the most effective substance for beef tenderisation using a curing process. Tenderness of culinary beef can also be improved by application of lactic acid.

References

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Table 1. The dynamics of colour stability changes in final beef products after 6, 12 and 24 h exposure to light (ΔE_6, ΔE_{12}, ΔE_{24}) (n=9)

Experimental groups		ΔE_6	ΔE_{12}	ΔE_{24}
C	x	2.27^b	2.67^b	3.55^b
	sd	1.19	1.15	1.94
CC	x	2.96^b	2.98^b	3.82^b
	sd	3.20	1.07	1.40
LA	x	2.00^b	2.98^b	3.93^b
	sd	0.74	1.19	2.06
BS	x	1.45^a	2.00^a	2.42^a
	sd	0.84	0.86	0.91

Table 2. The sensory evaluation of beef products: overall acceptability and colour (n=9)

Experimental groups		Overall acceptability	Colour
	x	4.57^b	4.28^b
C	sd	0.76	0.58
CC	x	4.40^b	4.37^b
	sd	0.62	0.61
LA	x	2.30^a	1.80^a
	sd	0.88	0.69
BS	x	5.28^b	5.10^c
	sd	0.82	0.86

a,b,c… - means within a column with different superscripts are significantly ($p \leq 0,05$) different.

Figure 1. Tenderness of final beef products evaluated by a sensory panel (n=9)

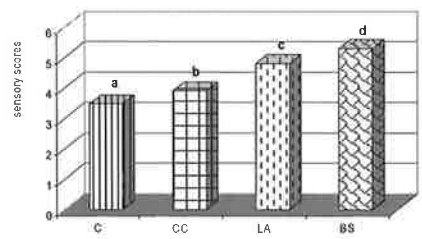
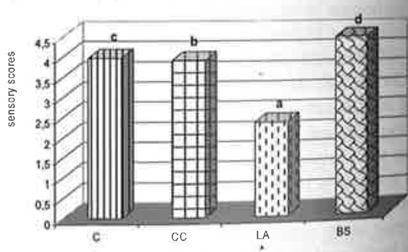


Figure 2. Flavour of final beef products evaluated by a sensory panel (n=9)



a,b,c… - different letter represents significant differences between groups ($p \leq 0,05$).