INDUSTRIAL EXPERIMENTS WITH LOW VOLTAGE ELECTRICAL STIMULATION OF BEEF CARCASSES IN POLAND

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SUMMARY

In experiments carried out in three meat plants in Poland the efficiency of low voltage electrical stimulation (LVES) applied at various time after stunning, possibility of improvement of export beef quality and accelerated beef processing using LVES were investigated. In order to rebuild the reserve of glycogen in muscles the animals in some experiments were fed on molasses solution before killing. It was found that to achieve good results in industrial conditions LVES must be applied not later than 5 min after stunning. Combination of feedind before killing and LVES gives considerable improvment of muscle red colour lightness at 24 h post-mortem what is important in selection for export purposes.In experiments concerning hot beef processing it was stated that LVES makes primal cutting and deboning easier.The biceps femoris muscles of heifer carcasses at 24 h post-mortem showed lighter colour in comparison with control muscles of non-stimulated cold boned carcasses.Also their tenderness was significantly greater. Meat production process was shortened and weight losses reduced.The quality of canned meat made of hot processed beef was slightly better and were no differences in quality of frankfurter-type sausages made of hot and cold boned meat.

INTRODUCTION

Research works on electrical stimulation (ES) of beef carcasses carried out for many years in Division of Meat and Fat Research Institute in Poznań (BORZUTA et al,1982a),(BORZUTA et al, 1982b),(KIEN,1990) showed positive effect of ES on the quality of beef. Research data coming from foreign literature were in these works verified in Polish conditions. Using the results of these works Polish industrial equipment for LVES was developed, constructed and installed in slaughterlines of 3 large meat plants: in Gorzów Wkp.(A), Jarosław (B) and Ostróda (C), (KIEN, BORZUTA,1988). Two of these plants seasonally carry out the beef export, mainly to Italy, where the light-red beef colour is required. In Poland about 10-20% of heifers and 50-80% of bulls gives DFD meat which cannot be exported because of dark colour. This is why the methods for improvement of meat colour lightness were looked for.One of these methods is ES but it is well-known that ES is effective only when tne animals have sufficient glycogen reserve in muscles before killing. The purpose of industrial experiments was to investigate the possibility of improvement of beef colour lightness and moreover - introduction of the accelerated beef processing including evaluation of quality traits of meat and some meat products made of hot boned, electrically stimulated carcasses.

MATERIALS AND METHODS

Heifers, dairy cows and young bulls of Fresian black-white breeds usually killed in slaughterlines without any selection were used. Carcasses were electrically stimulated for 1 min using Polish industrial apparatus with single polarity semisinusoidal output pulses with 80 V peak voltage and frequency 25 Hz. As electrodes the nostril tongs and transport rail of slaughterline were used. In experiments concerning LVES efficiency (expressed as pH decline) various starting time of stimulation was applied. In order to rebuild the glycogen reserve in muscles the animals in some experiments were fed once or several times on 6-10% molasses solution with addition of milk acid during 1 day before killing. The sides were chilled in standard way during 24 h. In experiments concerning accelerated beef processing the sides of stimulated carcasses were chilled only for 2.5-4 h in temperature from -3 to +2 ^{o}C respectively, what caused decreasing of core temperature somewhat below 30^{o}C. Control sides were chilled during 24 h in 2-4 ^{o}C. Following measurements were carried out: pH of longissimus dorsi (LD), biceps femoris (BF), semimembranosus (SM) and supraspinatus (SS) muscles at 2 h post-mortem (pH_2), extent of rigor mortis using IVO mechanical rigormeter and W-B shear force. Moreover sensory evaluation of meat and some meat products quality traits, determination of cooling and heating loss and chemical analysis of meat products were carried out.

RESULTS AND DISCUSSION

Table 1 presents mean pH_2 values of LD and BF stimulated with various delay after stunning. The muscle response decreases very fast with increase of LVES delay.Difference muscle response in left and right side (experiment III) is probably due to disappearance of nervous conductivity in unshackled right leg. With large delay LVES is practically not effective in both sides. It is consistent with statements of other authors who prefer applying of LVES not later than 5 min after stunning (CUTHBERTSON,1980), (ROZIER et al,1980).The results obtained by BUCHTER (1987) in Denmark were also confirmed in present study. In table 2 the results of investigation of the muscle response with LVES made as soon as possible i.e. 1-3 min after stunning are given. Relatively good efficiency of LVES is observed. Rigor was significantly advanced in stimulated carcasses as related to control ones (difference of 30-33% in measurements). It makes the hot boning easier. This was the reason why in other experiments LVES was always started within 1-3 min after stunning. In table 3 the results of sensory evaluation of LD muscle colour lightness in big groups of carcasses at 24 h post-mortem are given. All the mean values of visual evaluation were below 5.5 and in majority below 5.0 points. It means light-red LD muscle colour, fully accetable during selection of export beef "pistols" carried out at 24 h post-mortem. Non-stimulated carcasses in majority did not meet these requirements (data not given in the table). Other investigations (BORZUTA et al 1982a), (KIEN,1990) showed that while the animals were fed on molasses solution before killing LVES alone improved the muscle colour lightness by about 20 % (heifers) or 10 % (bulls). Using examined method the existing general proportion during the selection of carcass quarters for export purposes in both B and C plants was inverted because about 80% of carcasses with light-red meat colour was obtained. In table 4 the results of investigation of some meat quality traits of stimulated hot boned (ESHB) and non-stimulated cold boned (NSCB) heifer carcasses are given (experiment in meat plant C). Retail cuts from ESHB carcasses were chilled in containers in 2-4^{o}C. The retail cuts from ESHB carcasses (BF muscles) after 24 h and 48 h post-mortem showed lighter by 20% and 4% red colour respectively and at 48 h post-mortem better by 20% tenderness as expressed in W-B peak shear force measurements in comparison to cuts from NSCB carcasses. In sensory evaluation only cooked meat from ESHB carcasses showed slightly (but not significantly) better tenderness then the ones from NSCB carcasses. Smaller standard deviations in ESHB group suggests better uniformity of probes with respect to tenderness. No significant difference in cookin and roasting losses between ESHB and NSCB groups were found. The same reffers to taste and juiciness of meat probes (not given in the table). Meat production process was shortened and weight losses reduced from 2.34% to 1.87% due to reduction of total chilling time before expedition of retail cuts from 48 h to 24 h.

In meat plant B two batches of sterilized canned meat (4 assortments) made of ESHB and NSCB beef carcasses (5 heifers, 5 dairy cows and 3 young bulls in each group) were investigated. The animals in both groups were fed on the molasses solution once or twice during 1 day before killing. No significant differences in sensory evaluation of tenderness and taste of canned meat between both groups were found, but generally the scores in ESHB group were slightly better. In meat plant C two batches of frankfurter-type sausages in similar as above experiment pattern were made. In each group 5 heifers and 5 bulls (fed three times on the molasses solution during 1 day before killing) were used. Sausages contained 40% of beef. No significant differences as far as chemical composition, texture, flavour,taste and juiciness between sausages in both groups were found.

CONCLUSION

Experiments showed the possibility of introduction of LVES in some Polish meat plants. Combination of LVES with feeding of animals on the molasses solution before killing gives considerable improvement of red colour ligtness of meat what is particulary important in export beef production. This method is presently used in two meat plants. Moreover LVES makes carcass cutting and deboning easier and makes possible accelerated beef processing with all of the well

nown advantages. The quality of meat products made of hot processed beef is at least the ame as in case of products made of cold boned beef. However there are serious problems with ntroduction of this new technology in Poland since the structural changes and other impro- ements in existing meat plants and in animal husbandry are needed.

able 1. Muscle pH_2 of beef carcasses electrically stimulated after various delay and control carcasses in slaughterlines

Experiments	Cattle category	Group	Number of carcasses	Delay after stunning (min)	Mean pH_2 value of muscle		Meat plant
					LD	BF	
I	heifers	ES	28	4-6	6.26^a (0.36)	6.27^a (0.49)	A
		NS	26	-	6.76^b (0.18)	6.73^b (0.30)	
II	bulls	ES	10	6-8	6.58 (0.38)	6.48 (0.50)	A
		NS	10	-	6.81 (0.20)	6.51 (0.30)	
III	heifers	ES	20	6-8	-	5.99^a L	A
						6.46^b R	
IV	heifers	ES	20	8-10	6.58 L	6.48 L	C
					6.54 R	6.41 R	
		NS	20	-	6.51	6.81	
V	bulls	ES	15	8-10	6.81 L	6.47 L	C
					6.91 P	6.52 P	
		NS	15	-	6.80	6.67	

he animals were killed after 1 day fasting. In slaughterline carcasses were hanged on the ind left leg. Numbers in brackets indicate standard deviations. Numbers with different upper ubscript in given experiment and column differ significantly ($P<0.01$).
bbreviations: ES = electrically stimulated, NS = non-stimulated, L = left side, R = right arcass side.

able 2. Muscle pH_2 and rigor-mortis extent in beef carcasses electrically stimulated within 1-3 min after stunning and control carcasses in slaughterlines

Experiments	Cattle category	Parameter	Group	Number of carcasses	Mean pH_2 value of muscle				Meat plant
					LD	BF	SM	SS	
I	heifers	pH_2	ES	33	5.93	-	-	-	B
II	heifers	pH_2.	ES	26	5.96	-	-	-	C
III	heifers	pH_2	ES	30	6.37^a	6.01^a	-	-	C
IV			NS	30	7.05^b	6.66^b	-	-	
V	bulls	pH_2	ES	80	6.23	-	-	-	C
VI	bulls	pH_2	ES	30	6.11	-	-	-	C
VII	bulls	pH_2	ES	67	6.14	-	-	-	B
	heifers	rigormeter indication (mm)	ES	30	12.3^a	17.7^a	12.6^a	12.0^a	C
			NS	30	9.3^b	9.0^b	9.6^b	9.0^b	

he heifers in experiment I were fed on molasses solution twice during 1 day before killing. ulls in experiment V were fed four times as above. In other experiments the animals were ot fed before killing.
ll measurements were carried out randomly either in left or in right side. Rigor-mortis xtent was measured with rigormeter at 3 h post-mortem.
igures with different subscript in given experiment and column differ significantly ($P<0.01$).
S = electrically stimulated, NS = non-stimulated

Table 3. Sensory evaluation of red colour lightness of the LD muscle cross section of electrically stimulated beef carcasses at 24 h post-mortem

Experiments	Cattle category	Number of carcasses	Mean colour lightness in "Soicarni" scale	Meat plant
I	heifers	33	4.7	B
II	bulls	67	5.3	B
III	bulls	33	5.1	B
IV	heifers	66	4.9	C
V	bulls	30	4.9	C
VI	bulls	65	5.0	C
VII	bulls	67	4.6	C
VIII	bulls	67	4.8	C

Table 4. Some meat quality traits in BF muscle of stimulated hot boned (ESHB) and non-stimulated cold boned (NSCB) heifer carcasses (experiment in meat plant C)

Parameters	Time post-mortem (h)	Group ESHB (n = 30)	Group NSCB (n = 30)	Signifficance
visual evaluation of meat red colour	24	4.6 (0.8)	5.7 (0.8)	< 0.01
lightness using "Soicarni" scale	48	5.0 (0.3)	5.2 (0.5)	< 0.05
cooked meat tenderness:	48			
sensory evaluation		3.7 (0.5)	3.5 (0.6)	ns
W-B peak shear force (N)		110.2 (26.5)	138.9 (45.5)	< 0.01
roasted meat tenderness:	48			
sensory evaluation		3.9 (0.4)	4.0 (0.5)	ns
W-B peak shear force (N)		87.4 (15.8)	108.7 (23.0)	< 0.01
cooking loss (%)	48	40.7	41.9	ns
roasting loss (%)	48	42.7	43.9	ns

In experiments I-V (table 3) the animals were fed on the molasses solution twice during one day before killing and in experiments VI-VIII fed four times as above. In experiment showed in table 4 the animals were killed after one day of fasting. (Continued on the next page)

Meat colour "Soicarni" scale consists of 8 points (1 - lightest red colour, 8 - darkest red colour). Meat tenderness organoleptic scale consists of 5 points (1 - very tough meat, 5 - very tender meat). Figures in brackets indicate standard deviations.
n = number of carcasses, ns = not signifficant difference between ESHB and NSCB groups.

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