S. Afr. J. Anim. Sci. 7, 51–54 (1977)

EFFECT OF TECHNIQUE OF ELECTRICAL STUNNING ON MUSCLE pH AND MEAT QUALITY CHARACTERISTICS OF BACON PIGS

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Receipt of MS. 28.3.1977

OPSOMMING: INVLOED VAN TEGNIEK VAN ELEKTRIESE BEDWELMING OP SPIER pH EN VLEISKWALITEITSEIENSKAPPE VAN SPEKVARKE

'n Elektriese bedwelmer is gebruik om 18 Landras x Grootwit spekvarke te bedwelm waartydens 9 varke met 'n normale tegniek bedwelm is (kontrole) en 9 ander op 'n abnormale manier deur die elektrodes vir 45 s op verskillende dele van die vark se liggaam te plaas (behandeld). Na slagting is die pH, temperatuur, *rigor*, refleksie en gaarmaakverliese van spiere bepaal. Op geen een van die tydstippe nl. 0,25; 0,50; 0,75; 1; 3; 4 en 24 h *post mortem*, het die pH van die *M. longissimus lumborum* statisties betekenisvol tussen behandelings verskil nie. Die pH_1-waarde (45 minute *post mortem*) van dié spier was 6,30 ± 0,068 vir die kontrole en 6,22 ± 0,059 vir die behandelde varke. Op dieselfde tydstippe *post mortem*, was die pH van die *M. semimembranosus* statisties betekenisvol laer (P < 0,05) in die behandelde as in die kontrole varke. Die pH_1-waarde van die *M. semimembranosus* was 6,36 ± 0,050 vir die kontrole en 6,22 ± 0,030 vir die behandelde varke (P < 0,05). *Rigor* van die *M. semimembranosus* was 7,9 ±0,44 mm vir die kontrole en 10,0 ± 0,52 mm vir die behandelde varke (P < 0,01). Tussen behandelings was daar geen verskille in spiertemperatuur, refleksie of gaarmaakverlies nie. Alhoewel abnormale toepassing van elektriese bedwelming soos gebruik in hierdie eksperiment die *post mortem* pH van die *M semimembranosus* verlaag het, het dit nie die ekonomiese belangrike eienskappe, refleksie en gaarmaakverlies nadelig beïnvloed nie.

SUMMARY

Nine Landrace x Large White baconer pigs were stunned in the usual way by means of an electric stunner (control, normal stunning) while 9 other pigs were stunned in an unconventional way by applying an electric current for 45 s to various parts of the body (treated, abnormal stunning). Following slaughter, the pH, temperature, *rigor*, reflectance and cooking loss of muscles were determined. At not one of the stages viz. 0,25; 0,50; 0,75; 1; 3; 4 and 24 h *post mortem* the pH of the *M. longissimus lumborum* differed statistically significantly between treatments. The pH_1 was 6,30 ± 0,068 for the control and 6,22 ± 0,059 for the treated pigs. The *post mortem* pH of the *M. semimembranosus* was statistically significantly lower in the treated than in the control pigs at the afore-mentioned stages. The pH_1 of the *M. semimembranosus* was 6,36 ±0,050 for the control and 6,22 ± 0,030 for the treated pigs (P < 0,05). *Rigor* of the *M. semimembranosus* was 7,9 ±0,44 mm for the control and 10,0 ±0,52 mm for the treated pigs (P < 0,01). No significant differences were found in muscle temperature, reflectance or cooking loss between treatments. This led to the conclusion that although *post mortem* pH was lowered in the *M. semimembranosus*, the unconventional way of electrical stunning as applied in this experiment had no disadvantageous effects on the economically important characteristics namely reflectance and cooking loss.

During the course of surveys on the occurrence of PSE (pale, soft and exudative) pork at 6 pig slaughter centres in the Republic of South Africa, it was observed that the manner in which pigs were electrically stunned, varied markedly within and between centres. It was observed that the electrodes of the stunning instrument were not always applied directly to the temples of each pig and it so happened that pigs were electrically shocked for as long as 45 s on various parts of the body (Klingbiel, 1975). Lister (1970) and Ratcliff (1971) suggested that unskilled application of electric stunning of pigs could possible have undesirable effects on the eventual meat quality. Bendall (1966) demonstrated that direct electrical stimulation of excised muscle leads to an accelerated rate of *post mortem* glycolysis. Klingbiel & Naudé (1976) showed that stress immediately prior to slaughter also affects the rate of *post mortem* glycolysis in muscle which results in a pale colour and increased cooking loss of the meat.

It was decided to investigate, under experimental conditions, the effect of unconventional electrical stunning, as being practised in industry, on *post mortem* muscle glycolysis, *rigor* development, temperature, colour as well as cooking loss of the muscles of baconer pigs.

Procedure

Eighteen Landrace x Large White baconer pigs, raised under standard conditions, were used for this experiment. On reaching a live mass of 82 ± 5 kg, feed was withheld for one day from 2 previously selected pigs prior to slaughter. One pig was stunned in the normal way with an electric stunner (90 V) while the other was stunned abnormally. The treatments were randomly allocated. Nine pairs were slaughtered in this manner.

Control pigs (Normal stunning)

The electrodes of the electric stunner were applied to the moistened temples of the pig for 15 seconds.

Treated pigs (Abnormal stunning)

Before stunning the entire pig was sprayed with water to ensure proper electrical contact. The electrodes of the stunner were applied to the temples of the pig for 15 s followed immediately by placing the electrodes on the loin area (*M. longissimus lumborum*) for 10 s, followed by 5 s on the ham (*M. semimembranosus* and *M. biceps femoris*). The stunned pig was dragged from the stunning pen to the bleeding area (4 metres). The electrodes were then placed on the ham for a further 5 s, causing the hindleg to extend, facilitating easier shackling as noticed at some commercial abattoirs. Immediately before hoisting, the electrodes were applied to the temples again for 10 s. Simulating the stunning procedure followed at certain slaughter centres (Klingbiel, 1975) the animal was exposed to the electric current for 45 s i.e. 25 s on the temples and 20 s on the loin and ham areas.

After stunning, all the pigs were bled, scalded and eviscerated in a similar manner. Samples of the *M. longissimus lumborum* and *M. semimembranosus* were excised from the carcasses within 8 minutes *post mortem* and these samples kept at 37°C in a moist atmosphere saturated with nitrogen for 6 h. The course of *post mortem* glycolysis was followed by measuring the pH of the muscle samples at 0,25; 0,50; 0,75; 1; 2; 3; 4; 5 and 6 h *post mortem.* The remainder of the samples were then stored in a refrigerator at 2°C for 18 h following which the final pH was measured at 24 h *post mortem*. The technique used to determine the pH, *rigor*, temperature, reflectance and cooking loss of the muscles, were those as described by Klingbiel & Naudé (1976). An analysis of variance (Snedecor, 1966) was performed on the data.

Results and discussion

Muscle pH

The pH-values of the *M. longissimus lumborum* and *M. semimembranosus*, measured at different stages *post mortem*, are given in Table 1.

The data in Table 1 indicate that difference in the pH-values of the *M. longissimus lumborum* between the treatments was statistically significant only at 2 h *post mortem* ($P < 0,05$).

The pH_1-values (0,75 h *post mortem*) were 6,30 and 6,22 (difference not statistically significant for the control and treated groups respectively.

The pH-values of the *M. semimembranosus* of the treated group were statistically significantly lower than in the control group at 0,25; 0,50; 0,75; 1; 3 and 4 h *post mortem.* The pH_1-values were 6,36 and 6,22 for the control and treated groups respectively ($P < 0,05$). At 2 h *post mortem* the difference was statistically highly significant ($P < 0,01$).

At 5; 6 and 24 h *post mortem* there were no significant differences in pH-values for both muscles between treatments. This indicates that muscle pH-values of the 2 groups had already reached similar levels after 4 h *post mortem* which agrees with previous findings (Klingbiel & Naudé, 1976).

It is generally accepted that the *M. longissimus lumborum* and *M. semimembranosus*, with a low muscle

Table 1

Effect of technique of electrical stunning on post mortem *muscle pH*[a]

Muscle	*M. longissimus lumborum*			*M. semimembranosus*		
Time *post mortem*	Controls (n =9)	Abnormal stunning (n =9)	F-value	Controls (n =9)	Abnormal stunning	F-value
0,25 h	6,41 ± 0,046	6,36 ± 0,046	0,79	6,45 ± 0,049	6,30 ± 0,028	7,55*
0,50 h	6,34 ± 0,060	6,27 ± 0,052	0,89	6,39 ± 0,050	6,25 ± 0,035	5,31*
0,75 h	6,30 ± 0,068	6,22 ± 0,059	0,75	6,36 ± 0,050	6,22 ± 0,030	5,65*
1 h	6,30 ± 0,057	6,17 ± 0,069	2,27	6,32 ± 0,049	6,15 ± 0,469	5,99*
2 h	6,17 ± 0,052	5,88 ± 0,119	5,09*	6,20 ± 0,051	5,93 ± 0,061	12,37**
3 h	5,87 ± 0,095	5.65 ± 0,134	1,76	5,94 ± 0,112	5,61 ± 0,073	6,09*
4 h	5,60 ± 0,093	5,48 ± 0,126	0,59	5,72 ± 0,121	5,40 ± 0,079	4,85*
5 h	5,40 ± 0,067	5,43 ± 0,098	0,06	5,49 ± 0,108	5,34 ± 0,046	1,47
6 h	5,29 ± 0,031	5,34 ± 0,084	0,37	5,35 ± 0,034	5,29 ± 0,034	1,57
24 h	5,28 ± 0,033	5,28 ± 0,037	0,17	5,30 ± 0,034	5,27 ± 0,038	0,21

a Mean of three pH-measurements ± standard error

** $P < 0,01 = 8,28$

* $P < 0,05 = 4,41$

pH and high muscle temperature at 45 minutes *post mortem* (Briskey, 1964; McLoughlin, 1965) are 2 of the muscles particularly inclined to develop poor meat quality characteristics.

From the results in this paper it is clear however, that the *post mortem* pH-values of the *M. semimembranosus* were affected more severely than those of the *M. longissimus lumborum*, which is in agreement with some of the findings of Eikelenboom (1974). He found that under certain conditions the *post mortem* pH of the *M. semimembranosus* can be lower than or the same as the pH of the *M. longissimus lumborum*. Lawrie (1960) mentions that struggling of the animal during slaughter causes the *post mortem* pH of certain other muscles to be lower than that of the *M. longissimus lumborum*. The additional electric current applied to the ham of the treated pigs in this experiment most probably caused the *M. semimembranosus* to respond to a greater extent than the *M. longissimus lumborum* in terms of rate of *post mortem* glycolysis.

Table 2 contains the results of the other meat quality characteristics.

Table 2

Effect of technique of electrical stunning on certain muscle characteristics [a]

Characteristic	Controls (n =9)	Abnormal stunning (n =9)	F-value
T_{45} LL (°C)	38,5 ± 0,39	38,2 ± 0,43	0,37
T_{45} SM (°C)	38,6 ± 0,33	38,5 ± 0,42	0,04
Rigor SM (mm)	7,9 ± 0,44	10,0 ± 0,52	10,14**
Reflectance LL (%)	31,4 ± 0,95	32,4 ± 0,63	0,59
Reflectance SM (%)	32,7 ± 1,39	29,9 ± 1,94	1,43
Cooking loss LL (%)	28,5 ± 0,69	29,8 ± 0,76	1,74
Cooking loss SM (%)	28,9 ± 1,27	28,8 ± 1,08	0,01

a Mean value ± standard error

T_{45} Muscle temperature 45 minutes *post mortem*

LL *M. longissimus lumborum*

SM *M. semimembranosus*

**P < 0,01 = 8,28

P < 0,05 = 4,41

Muscle temperature

There were no statistically significant differences in muscle temperature between treatments. Van Logtestijn (1969) maintains that a low meat quality, of which an accelerated rate of *post mortem* muscle pH fall is a symptom, is not necessarily accompanied by a rise in muscle temperature. Therefore, although the abnormal way of electrical stunning in this experiment decreased the pH of the *M. semimembranosus*, it was not sufficient to increase the muscle temperature.

Rigor

According to the data in Table 2 the *rigor*-value of 10 mm measured on the *M. semimembranosus* of the treated pigs was statistically significantly higher than the 7,9 mm measured for the control pigs ($P < 0{,}01$). Sybesma (1966) and Klingbiel & Naudé (1976) similarly found higher *rigor*-values in muscles with low pH_1-values.

Reflectance

There were no significant differences in reflectance values between treatments (Table 2). McLoughlin & Goldspink (1963) mentioned that sarcoplasmic protein precipitation, which masks the colour of the muscle myoglobin and therefore gives meat a paler appearance, is due to a combined effect of low pH and high muscle temperature. Lister (1970) also states that the change in muscle colour appears to be a function of muscle temperature when a particular pH-value is reached. McDougall & Disney (1967) recorded high reflectance values in muscles with a low pH_1 concomitant with a high temperature.

Although a significantly ($P < 0{,}05$) lower *post mortem* pH of the *M. semimembranosus* was found in this experiment (Table 1), the muscle temperature was not significantly affected and this could probably be the reason why the reflectance of the muscles was not affected differently by the 2 treatments. It is also possible that the pH-values, which remained near 6 even after 2 hours storage, prevented any large precipitation of sarcoplasmic proteins.

Cooking loss

The cooking loss of 100 g meat samples did not differ between treatments. Higher drip loss, poorer water binding capacity and therefore a higher cooking loss, are caused by a combination of high temperature and low pH in the muscle (Wismer-Pedersen, 1969; Lister, 1970). These conditions did not prevail in the muscles of the treated animals, hence the result that no differences were observed in the cooking loss of the muscles of the two groups of pigs.

Conclusions

Unconventional electric stunning as applied in this experiment, caused the rate of *post mortem* pH decline in the *M. semimembranosus* to be significantly increased. The experimental treatment was however not of such a drastic nature as to lower the pH of the *M. longissimus lumborum* or cause a higher muscle temperature in either of the 2 muscles. Consequently, reflectance and cooking loss of the meat were not detrimentally affected by the abnormal electrical stunning of pigs. The more rapid pH-fall in the *M. semimembra-*

nosus of the treated pigs, does however point to the stress effect on muscles which are electrically stimulated.

Since stress resistant pigs were used in this experiment, one could only speculate on the effects which the experimental treatment would have had on stress súsceptible pigs. Had stress susceptible pigs been used, one would expect that they would have been more readily affected by this particular way of electrical stunning than stress resistant pigs, possibly by showing a faster rate of pH-decline, higher reflectance and greater cooking loss.

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