EFFECT OF HOT BONING, ELECTRICAL STIMULATION AND PI-VAC POST MORTEM INTERVENTIONS ON THE PHYSICO-CHEMICAL CHARACTERISTICS AND EATING QUALITY OF PORK M. LONGISSIMUS THORACIS ET LUMBORUM MUSCLES FROM PIETRAIN AND DUROC PIG BREEDS

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Abstract – This study involved the application of post mortem interventions: hot boning, electrical stimulation and Pi-vac to pork longissimus thoracis et lomborum (LTL) muscles in two pig breeds (Pietrain and Duroc). After carcasses were split, the LTL muscle was excised from one side and one of the following five treatments was randomly assigned: low-voltage electrically stimulated at 85 V for 30 s (HBES); Pi-vac wrapped (HBPI); low-voltage electrically stimulated and Pi-vac wrapped (HBESPI) or no treatment (HB). The other side of each carcass was cold-boned and chilled at 2-4 °C before excision of the LTL (CB) at 24 hours post mortem. Muscles were aged for seven days prior to cutting of individual steaks which were frozen and stored (-20 °C) for analysis (pH, weight loss, NMR relaxometry, colour, texture, protein degradation (SDS-PAGE) and sensory characteristics). Greater differences between treatments were observed for the Pietrain than for the Duroc breed. HBPI samples were more tender than their HB and the HBESPI counterparts. This was supported by sensory data (although for less treatments) in which panellists rated HBPI as more tender ($p<0.05$) than the HB treatment. However, no differences were observed for drip loss, NMR relaxometry and protein degradation in either breed.

Key Words – hot boning, Pi-vac, low-voltage electrical stimulation, pork, sensory.

I. INTRODUCTION

Intensive production of pigs has resulted in a highly efficient pork production system, however, there is concern that the eating quality has been compromised i.e. the succulence of pork has been reduced due to its lower intramuscular fat (IMF) content [1]. Post mortem interventions could help to ameliorate this negative effect on eating quality, having proved to be successful in both beef and lamb processing [2, 3]. Electrical stimulation involves the application of an electrical current through a carcass or a muscle and effectively hastens the process of rigor mortis by accelerating post mortem glycolysis, thereby lowering the early pH and increasing the rate of pH decline [4]. Therefore, it is a valuable tool for avoiding conditions such as cold and heat shortening which would otherwise result in less tender meat even after ageing. Electrical stimulation should be considered as part of a total process as it has particular advantages for ultra-fast cooling and hot boning applications. Hot boning involves the removal of muscles or cuts up to 90 minutes post-mortem. The advantages of hot boning are reductions in the weight loss during chilling and in drip losses during storage, due to the increased WHC of the muscle proteins at the higher pH while at the same time reducing chilling costs compared to conventional boning practices. The Pi-vac Electro-Pack System is a wrapping technique that is applied to pre-rigor hot-boned muscles using an elastic wrapping material to prevent shortening and toughening of the meat during rigor [5]. It operates by stretching tubes of highly elastic films to the inside walls of a packing chamber using a vacuum. The longitudinal forces exerted by the elastic film hinder muscle contraction during rigor [6]. As much of the early research in *post mortem* interventions was carried out in pork, it would be of benefit to revisit this line of research and investigate if further developments can be made using this new technology to overcome the negative effects of hot boning. The principal objective of the present study was to perform a detailed characterization of the effects of hot boning, electrical stimulation and Pi-vac separately and in combination on the physico-chemical and eating quality of pork (M. *longissimus et lomborum*) in two breeds (Piétrain and Duroc).

II. MATERIALS AND METHODS

Pietrain and Duroc gilts (n = 12/breed) of a similar weight and age were slaughtered in a pilot scale abattoir. All boning and *post mortem* interventions were randomised with respect to carcass side so that all treatments occurred equally on both the left and right sides over the course of the experiment. Carcasses were centrally split into left (n=12) and right hand sides

(n=12). One side of each carcass was hot-boned within 40 min *post mortem* and the other half was chilled conventionally (control). The M. *longissimus thoracis et lumborum* (LTL) muscle was excised from each of the hot-boned sides and assigned to one of four treatments: low-voltage electrically stimulated at 85 V for 30 s **(HBES)**; Pi-vac wrapped **(HBPI)**; low-voltage electrically stimulated and pi-vac wrapped **(HBESPI)** or no treatment **(HB)**. The other side of each carcass was chilled at 2-4 °C before excision of the LTL muscle **(CB)** at 24 hours *post mortem*. All cold- and hot-boned muscles were vacuum packed and stored at 2-4 °C for 7 days *post mortem*. Physico-chemical characteristics of pH, weight loss, NMR relaxometry, instrumental colour) CIE lab L*, a* and b*), instrumental texture (Warner Bratzler Shear Force (WBSF)), protein degradation (SDS-PAGE) and eating quality were subsequently measured. Analysis of variance (ANOVA) was carried out using Tukey-Kramer pairwise comparisons with the significance for treatment differences set at $p<0.05$.

III. RESULTS AND DISCUSSION

pH

Overall, significantly more variation was observed in samples from Pietrain pigs compared to their Duroc counterparts. Early post mortem pH values are important in relation to the rate of temperature fall due to the increased risk of cold-shortening which results in tougher meat. Figure 1 shows the pH decline over the first 20 hours post mortem for all treatments. These data indicate that the application of low voltage electrical stimulation increased the rate of pH decline, particularly in the case of the combined treatment **(HBESPI)**. This trend is in line with expectations and with the scientific literature [7]. However, a similar trend was not observed for samples from Duroc pigs.

Physico-chemical characteristics and eating quality

Table 1 shows the results for selected quality characteristics of fresh pork from two breeds. There were no significant differences in drip loss between treatments in samples from either breed. This was supported by the NMR relaxometry observations that showed no significant differences between treatments in the T22 population (usually associated with free/unbound water). Furthermore, there were no significant differences between treatments in instrumental colour values (only redness, a*, shown). Warner-Bratzler shear force ranged between 19.5 and 35.3 N and there were significant differences between treatments ($p<0.001$). Hot-boned samples that underwent Pi-vac treatment (HBPI) post mortem were more tender than their hot-boned (HB) and combination treatment (HBESPI) counterparts. Cold-boned (CB) samples were more tender than hot-boned (HB) and hot-boned and electrically stimulated samples (HBES). These findings were at least partially supported by sensory data since the panellists rated HBPI as more tender (higher score) than the HB treatment ($p<0.05$). This is in line with previous work on beef, which showed significant improvements in the texture (WBSF) and sensory tenderness of Pi-vac wrapped LD beef steaks compared to controls [3]. In the case of Duroc samples, no significant differences were observed in either instrumental (WBSF) or sensory texture. This difference between the two breeds in their apparent response to these post mortem interventions merits further investigation.

SDS-PAGE analyses

Figure 2 shows a scan of protein separation carried out using SDS-PAGE and a GS-800 densitometer (BioRad). The wide range molecular marker (Sigma-Aldrich, Dublin) appears in the lane farthest to the right (molecular weights of the extremes are noted). Between 15-17 bands were separated in each lane for all treatments. Myosin (heavy chain) and actin were the most intense bands within the gel for all treatments. No significant differences between the treatments in the banding patterns were observed, suggesting that the post mortem interventions did not have any meaningful effect on the rate of post mortem proteolysis.

IV. CONCLUSION

Post mortem interventions have the potential to improve the efficiency of pork primary processing without compromising on meat quality. The Pi-vac pre-rigor wrapping technique appears to offer protection against the negative effects of hot-boning in much the same way as in beef since hot-boned samples that had been wrapped by the Pi-vac technique were at least as tender as cold-boned control samples. This implies potential for this line of research that was previously abandoned due to the risk of PSE in pork. These initial investigations are encouraging due to the successful integration of these post-mortem intervention practices in beef and lamb meat management chains. Although the differences between treatments were significant only within the Pietrain breed, there were no negative effects of hot boning and Pi-vac for the Duroc breed. Electrical stimulation either alone or combined with Pi-vac seems to offer no benefit, which would simplify the application of the Pi-vac technology.

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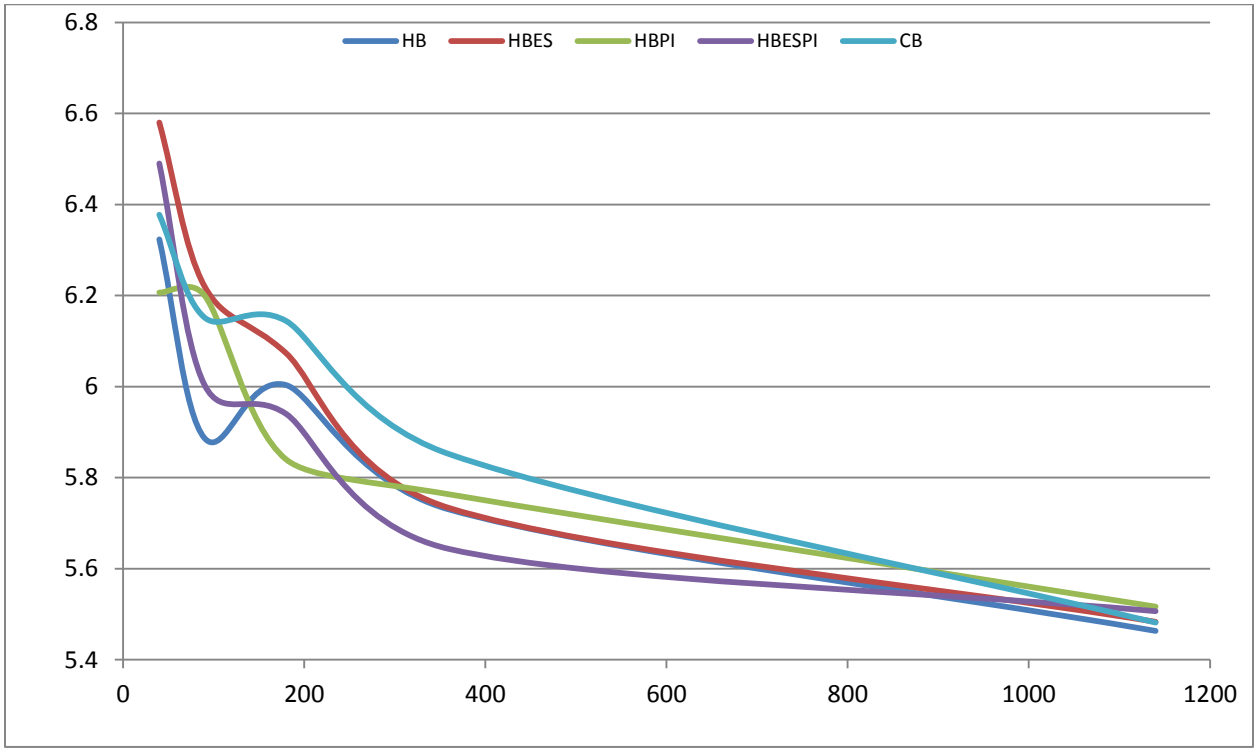

Fig. 1: Effect of treatments on pH decline (Y-axis) post-mortem over time (x-axis; min)

Table 1. The effects of post mortem interventions on selected quality indices of fresh pork

	Drip loss (%)		T22 (%)		a*		WBSF (N)		Initial tenderness	
	Pietrain	Duroc	Pietrain	Duroc	Pietrain	Duroc	Pietrain	Duroc	Pietrain	Duroc
CB	2.6[a]	2.4[a]	2.1[a]	3.9[a]	6.1[a]	6.6[a]	22.8[ab]	24.2[a]	48.9[ab]	48.6[a]
	0.8±	1.2±	2.3±	2.1±	1.1±	1.5±	5.5±	7.5±	10.4±	10.9±
HB	3.3[a]	2.4[a]	1.7[a]	4.2[a]	6.7[a]	5.8[a]	35.3[c]	23.4[a]	37.4[a]	51.3[a]
	±1.3	±1.7	±0.8	±2.9	±1.1	±0.1	±8.3	±4.4	±16.1	±9.9
HBES	2.5[a]	1.8[a]	2.2[a]	3.9[a]	5.9[a]	5.8[a]	34.0[c]	24.6[a]	40.4[ab]	52.0[a]
	±0.7	±0.6	±2.0	±2.9	±1.7	±0.8	±8.9	±2.0	±13.5	±7.3
HBPI	2.4[a]	1.2[a]	2.2[a]	2.2[a]	6.9[a]	6.4[a]	19.5[a]	24.8[a]	64.9[b]	55.2[a]
	±0.3	±1.0	±1.1	±1.1	±1.8	±2.4	±7.0	±3.7	±2.0	±1.2
HBESPI	1.3[a]	1.9[a]	1.6[a]	5.3[a]	6.2[a]	6.6[a]	25.9[b]	25.9[a]	44.8[ab]	47.3[a]
	±1.2	±1.4	±1.4	±2.5	±0.3	±3.0	±4.3	±4.2	±10.6	±8.7
SEM	0.20	0.24	0.27	0.34	0.24	0.33	0.70	0.54	2.59	1.86

Different letters in a column indicate significant differences according to Tukey-Kramer Test ($p<0.05$)
SEM: standard error of the means, WBSF: Warner-Bratzler Shear Force; CB: cold-boned; HB: hot-boned; HBES; hot-boned electrically stimulated; HBPI: hot-boned and pi-vac; HBESPI: hot-boned, electrically stimulated and pi vac

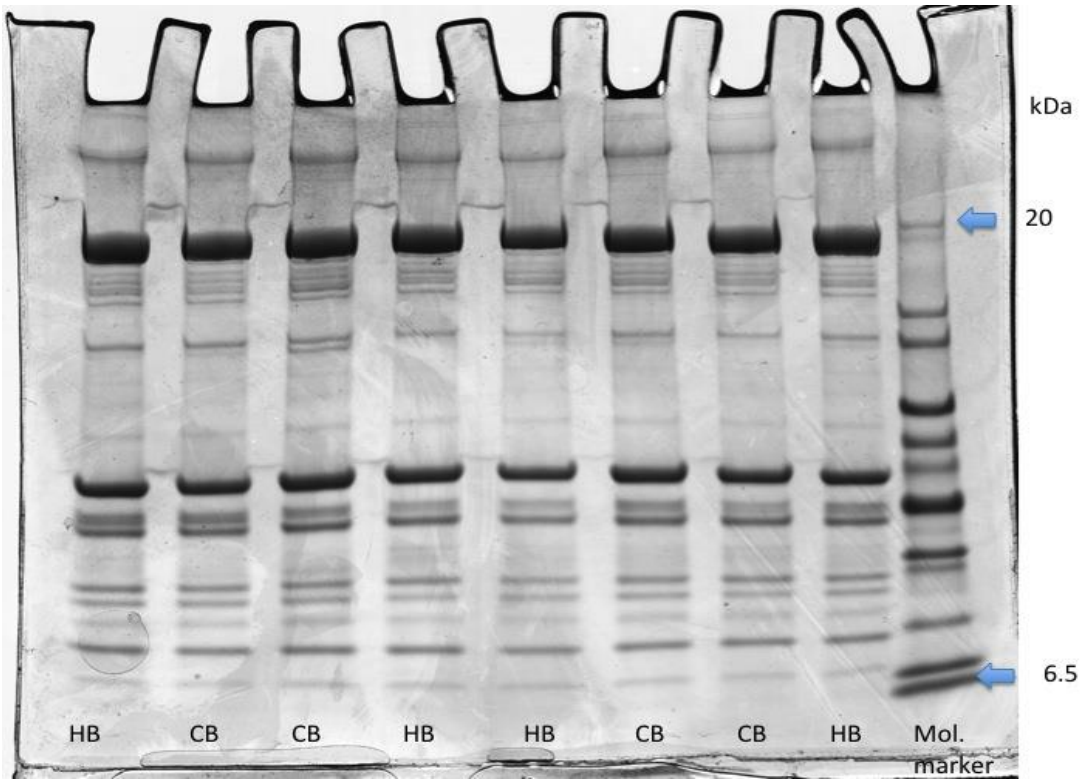

Fig.2. SDS-PAGE gel of protein separation for all treatments after seven days aging