THE AGEING RATE OF PORK UNDERGOING ACCELERATED PROCESSING AND TEMPERATURE CONDITIONING.

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Introduction:

Consumers consider tenderness to be one of the most important components of meat quality. To improve the consistency of meat quality with respect to tenderness, meat should be aged. There are differing views on the post mortem ageing period for optimal tenderisation for pork with recommendations ranging from 2 to 8 days post slaughter for cold boned pork with further conflicting views on whether accelerated processed meats do age. The objective of experiment 1 was to determine the ageing rate at 4°C of pork boned at rigor and of experiment 2 was to determine the effect of accelerated boning and temperature conditioning at 0 or 14°C on rate of ageing at 4°C and meat quality compared with pork boned after rigor and aged at the same temperature.

Materials and Methods:

Experiment One:

Four female Large White x Landrace pigs were slaughtered and the carcasses chilled. The pH of the *M. longissimus thoracis et lumborum* (LTL) was monitored every 60 min. at the 5th/6th lumbar vertebrae until rigor mortis had set in as defined by pH $\leq$ 5.7. The LTL muscle was removed at 60 min. post rigor and cut into twelve 150 g samples. These samples were randomly allocated to an ageing period, vacuum packaged and stored at 4°C. The ageing period treatments were 7, 13, 19, 25, 31, 43, 55 hours, 3, 4, 5, 7, and 9 days post slaughter and fresh samples were analysed for Warner-Bratzler (W-B) peak shear force (kg) at each of these times after cooking for 60 min. in an 80°C water bath.

Experiment Two:

Fifteen pigs were slaughtered and at 30 min. post slaughter the sides were randomly allocated to temperature/boning treatments of (i) rigor boning (RB) - LTL muscle boned at 60 min. post rigor after sides being chilled at 4°C, (ii) accelerated boning and held at 0°C (AB-0) or (iii) 14°C (AB-14) - LTL muscle boned within 30 min. post slaughter and either placed in an ice water or 14°C water bath until 60 min. post rigor. The pH of the LTL muscle was monitored until pH $\leq$ 5.7 as for experiment 1 and left for 60 min.. All LTL muscles were randomly allocated to an ageing period of 11, 19, 25, 31 hours, 2, 3, 4, 6, 8, and 10 days and were cut into eleven 150 gram samples, vacuum packaged and stored at 4°C. Samples were analyzed for W-B peak shear force. At 60 min. post rigor and 4 days post slaughter, pH and colour (CIE-L*, a*, b*) were assessed and 50 g samples snap frozen in liquid nitrogen and stored at -80°C for later assessment of myofibrillar fragmentation index (MFI) (Culler *et al.*, 1978), and sarcomere length. Drip loss was assessed at 60 min. post rigor as described by Honikel *et al.* (1986). To determine the rate of pH decline, temperature decline and rate of ageing, the average data was fitted to an exponential decay equation using Genstat 5. Meat quality characteristics were analysed using the ANOVA function of Genstat 5.

Results:

The equation parameters for the rate of change in pH, temperature and W-B peak shear force are given for experiment 1 and 2 in Table 1 and the change in W-B peak shear force is shown graphically in Figure 1. As no ageing occurred in the AB-0 muscles in experiment 2, the R^2 is zero. Except for the pH decline and change in shear force of AB-0 muscle, all other data in experiment 1 and 2 fitted the exponential decay function.

In experiment 2, the AB-0 muscle had a darker colour and a higher drip loss relative to both RB and AB-14 muscle at 60 min. post rigor (Table 2). At 4 days post slaughter the RB muscle had a higher pH relative to the AB-0 and AB-14 treated muscle while the AB-14 muscle was lighter in surface colour. At 60 min. post rigor and 4 days post slaughter, processing method did not influence the sarcomere length of the muscles. At 60 min. post rigor, the method of processing did not effect the MFI while by four days post slaughter, AB-0 muscle had a lower MFI relative to both RB and AB-14 muscle.

Discussion:

In experiment 1, 50% of the tenderisation for RB muscle occurred within two days which is similar to results of Dransfield *et al.* (1980-81). In experiment 2, 50% of the tenderisation in RB muscle was achieved by 6 days post slaughter. This variation in ageing rate between the two experiments may be explained by the slower rate of pH decline and faster temperature decline post slaughter in experiment 2 as seen in their rate constants. This variation in rigor development can alter muscle structure, the release of calcium ions from the sarcoplasmic reticulum and the activity of proteolytic enzymes (Dransfield, 1994) with higher temperatures accelerating the glycolytic process. Therefore, the faster decline in muscle temperature in the RB muscle in experiment 2 resulted in a slower pH decline which probably influenced the subsequent rate of tenderisation.

Fifty percent of tenderisation for the AB-14 muscle occurred within two days post slaughter with a similar rate constant to that seen for the RB muscle in experiment 1. However, the AB-0 muscle did not age at all over the 10 day ageing period. This lack of ageing could not be explained by cold shortening as there was no decrease in sarcomere length relative to the AB-14 and RB muscles suggesting shortening occurred in all treatments. The increase in sarcomere length with ageing also did not correspond with an improvement in tenderness of the AB-0 muscle. The AB-0 muscle was seen to have a much higher drip loss when measured at 60 min. post rigor which maybe attributed to a greater shrinkage of myofibrils causing a greater portion of free water which can be lost from the meat. In conclusion, the ageing rate of pork undergoing accelerated boning held at 14°C and aged at 4°C was similar to post rigor boned pork aged at 4°C in experiment 1, in contrast to accelerated boned pork held at 0°C which did not age at all.

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References:
Culler R. D., Parrish F. C., Smith G. C. and Cross H. R. (1978) *Journal of Food Science* **43:** 1177-1180.
Dransfield E., Jones R. and Macfie H. (1980-81) *Meat Science* **5:** 139-147.
Dransfield E. (1994) *Meat Science* **36:** 105-121.
Honikel K. O., Kim C. J., Hamm R. and Rocales P. (1986) *Meat Science* **16:** 267-282.

Table 1. Rate equation parameters determined for pH decline, temperature decline and the changes in Warner-Bratzler peak shear force for *pork M. longissimus thoracis et lumborum* for experiment 1 and 2.

Treatment		F∞	Fo-F∞	k	R^2
RB - expt 1	pH	5.58	1.17	0.27	96.3
RB - expt 2		5.01	1.63	0.06	96.8
AB-0		11.10	-4.3	-0.02	88.2
AB-14		3.08	3.71	0.03	96.4
RB - expt 1	temperature	8.42	23.20	0.41	93.7
RB - expt 2		5.78	32.02	0.35	99.2
AB-0		2.08	32.76	1.34	99.9
AB-14		14.00	20.89	1.29	99.5
RB - expt 1	Warner-Bratzler	4.08	3.71	0.38	92.4
RB - expt 2	Peak Shear Force	8.77	-0.37	-0.19	61.9
AB-0		9.183	0	-	0
AB-14		5.39	2.87	0.3	87.9

The average pH, temperature and shear force data was fitted to $F_t = F_\infty + (F_o - F_\infty)\, e^{-kt}$ where F_o is value at time zero (30 min. post stunning for pH and temperature, 60 min. post rigor for ageing), F_t is time t, F_∞ is at completion and k is the rate constant. Time is in hours for pH and temperature and days for Warner-Bratzler peak shear force. R^2 = the percentage variation accounted for by the equation.

Table 2. Treatment means for meat quality, sarcomere length and myofibril fragmentation index (MFI) for pork *M. longissimus thoracis et lumborum* at 60 min. post rigor and 4 days post slaughter for the three different processing methods [1]

		RB	AB-0	AB-14	sed
pH	4 days	5.56^{b}	5.48^{a}	5.48^{a}	0.030
Surface lightness (L*)	60 min post rigor	43.1^{b}	39.9^{a}	44.0^{b}	1.55
	4 days post slaughter	49.8^{a}	49.3^{a}	51.5^{b}	0.51
drip loss (%)		2.8^{b}	4.6^{c}	1.3^{a}	0.71
sarcomere length (µm)	60 min post rigor	1.49	1.49	1.56	0.097
	4 days post slaughter	1.66	1.68	1.75	0.054
MFI	60 min. post rigor	58.8	71.6	89.6	11.93
	4 days post slaughter	104.5^{b}	73.4^{a}	123.1^{b}	12.49

[ab] within rows, means with different superscripts are significantly different (P<0.05), [1]RB= post rigor boning; AB-0 = accelerated processing and held at 0°C in an ice water bath; AB-14 = accelerated processing and held in a 14°C water bath.

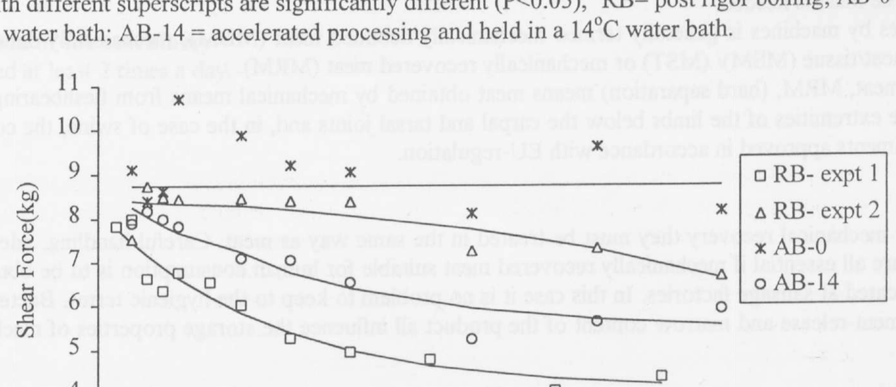

Figure 1. Changes in Warner-Bratzler peak shear force of pork *M. longissimus thoracis et lumborum* during ageing at 4°C; 1/ after post rigor boning (RB) (experiment 1 and 2), and 2/ accelerated processing held at 0°C (AB-0) and accelerated processing held at 14°C (AB-14) (experiment 2).