THE EFFECT OF PHOSPHATE LEVEL AND TUMBLING TIME ON HOT AND COLD BONED CURED PIGMEAT PRODUCTS

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Introduction

Hot boning, the removal of muscles from the still hot carcass, was developed in response to commercial demands for lower energy use and chilling space requirements (Taylor *et al*., 1995). Accelerated boning of meat carcasses has been conducted for a number of years. Accelerated boning enables production costs to be reduced due to lower labour requirements, a reduction in chiller space, energy input and increased product turnover (Cross and Seideman, 1985). Wide-scale accelerated boning of pork has yet to be employed, largely due to the reluctance to employ new systems and the potential detrimental impact on tenderness resulting from the rapid drop in muscle temperature that occurs when muscles are removed pre-rigor (Rees *et al*., 2002). There is much emphasis now on healthier products and ingredients within the food sector. Reduced phosphate levels would meet the demand for healthier brine formulations. A reduced tumbling time would have economical benefits and increased product turnover for the processor. The present study was designed to determine the optimal combination of methods in order to improve overall pork quality and maximize tenderness following accelerated boning.

Objectives

The main objective of this study was to investigate the effect of two phosphate levels (1.25 and 2.50%) and two tumbling rates (4 and 16 hours) on hot and cold boned hams and shoulders.

Methodology

The right hand sides of 24 Large White x Landrace pork carcasses were hot boned (HB) at a local abattoir immediately after slaughter. The left sides were chilled at 1ºC for 24 hours *postmortem* before cold boning (CB). The HB and CB legs and shoulders were then cured using 2 levels of phosphate (1.25 or 2.50%) and 2 intermittent tumbling rates (short [4 hours] or long [16 hours]). The meat was vacuum packed in cook in-shrink bags (Cryovac BB4L) and placed in ham moulds. The legs and shoulders were cooked in dry heat, to an internal temperature of 80ºC for 8-9 hours (h). Samples of hams and shoulders were stored under MAP (70%N_2, 30%CO_2) conditions in visual display units (4ºC, 616 lux) for up to 28 days.

Colour measurements were made using a Cr-300 Chromameter (Minolta Co. Ltd, Japan) set on the Hunter colour scale and reported as the 'L' lightness, 'a' redness and 'b' yellowness values (after 7, 14 and 21 days of retail storage). Warner Bratzler shear force (tenderness) values were measured on a texture analyzer (Stable Micro Systems, UK) and results expressed in kg (after 1, 7, 14, 21 and 28 days of retail storage). Lipid oxidation was measured by the distillation method of Tarladgis *et al*. (1960) as modified by Ke *et al*. (1977) and results were expressed as 2-thiobarbituric acid reactive substances (TBARS) in mg malondialdehyde/kg muscle (after 1, 7, 14, 21 and 28 days of retail storage).

Results & Discussion

Phosphate added at the lower, 1.25% level, resulted in greater lipid stability of cooked hams and shoulders during retail storage at 4ºC. Ham TBAR values were lower after 1 ($p<0.001$), 7 ($p<0.001$) and 28 ($p<0.01$) and cooked shoulders after 1 ($p<0.001$) and 21 ($p<0.01$) days of storage. Tumbling for 4 h resulted in lower oxidation values of hams and shoulders after 7 ($p<0.001$), 14 ($p<0.001$) and 28 ($p<0.01$) storage days. A combination of lower phosphate levels and shorter tumbling time significantly reduced lipid oxidation during retail storage.

Warner Bratzler shear force (WBSF) values were lower in hams in the higher, 2.5% phosphate, treatment group after 1 ($p<0.01$), 7 ($p<0.001$), 14 ($p<0.05$) and 28 ($p<0.01$) days of storage. A slight ($p<0.05$) difference in tenderness was observed between hot and cold boned hams after 21 days of retail storage only.

Overall lower yield values were reported for HB hams (87.75%) and shoulders (84.22%) compared to their CB counterparts, 90.45% and 91.23%, respectively. It has been suggested that increased water holding capacity of HB meat may be diminished by cold shortening brought on by injection of deep chilled brine (Pisula and Tyburcy, 1996). In this study tumbling time did not have a significant effect on water holding capacity of hams or shoulders (results not shown).

Statistical analysis showed that CB cooked shoulders had higher ($p<0.05$) 'L' lightness values than HB samples. Tumbling for 4 h improved the 'a' redness values of shoulders after 7 ($p<0.05$) and 21 ($p<0.01$) days in a retail display unit.

Conclusions

A combination of lower phosphate levels and shorter tumbling time significantly reduced lipid oxidation during retail storage. Warner Bratzler shear force (WBSF) values were lower in hams in the higher, 2.5% phosphate, treatment group during retail storage. Overall lower yield values were reported for hot boned hams and shoulders compared to cold boned samples.

References

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Tables and Figures

Table 1. Effect of phosphate level and tumbling time on Hunter lightness (“L”), Hunter redness (“a”), TBARS, cook loss and Warner Bratzler shear force (mean ± standard deviation) values of cooked hams stored in modified atmosphere packs (70% N_2, 30% CO_2) at 4ºC.

	Carcass Side	Treatment Group	Storage time, days				
			1	7	14	21	28
“L”	Hot-boned	Control		55.30 ± 2.66	56.32 ± 2.19	56.58 ± 2.20	
		Short T		55.96 ± 3.57	54.10 ± 2.48	57.05 ± 2.82	
		Low P		52.81 ± 6.93	57.15 ± 4.72	55.42 ± 3.24	
		Low P, short T		55.79 ± 3.77	55.34 ± 5.18	55.99 ± 3.05	
	Cold-boned	Control		58.20 ± 3.96	59.49 ± 2.80	58.18 ± 3.48	
		Short T		56.64 ± 2.68	53.88 ± 3.41	57.24 ± 3.55	
		Low P		58.42 ± 1.97	56.42 ± 4.62	56.06 ± 4.79	
		Low P, short T		57.48 ± 2.99	55.29 ± 4.35	57.93 ± 3.51	
“a”	Hot-boned	Control		7.23 ± 0.83	6.77 ± 0.90	7.12 ± 1.08	
		Short T		7.96 ± 0.92	7.78 ± 0.93	8.54 ± 0.60	
		Low P		8.73 ± 1.52	7.61 ± 1.11	8.11 ± 0.65	
		Low P, short T		8.12 ± 1.33	8.12 ± 1.03	4.76 ± 1.15	
	Cold-boned	Control		6.82 ± 1.04	6.76 ± 0.72	7.21 ± 0.26	
		Short T		8.14 ± 0.80	7.66 ± 1.33	8.53 ± 0.64	
		Low P		8.17 ± 1.42	8.10 ± 1.39	7.88 ± 1.04	
		Low P, short T		7.95 ± 1.69	7.38 ± 1.33	7.52 ± 1.92	

‘b’	Hot-boned	Control		7.37 ± 0.75	7.14 ± 1.07	7.56 ± 0.92	
		Short T		7.11 ± 0.77	7.19 ± 0.71	8.07 ± 0.61	
		Low P		6.97 ± 1.41	7.85 ± 1.06	7.34 ± 0.77	
		Low P, short T		7.67 ± 0.98	8.08 ± 0.93	8.06 ± 0.64	
	Cold-boned	Control		7.50 ± 0.98	7.13 ± 0.91	7.64 ± 0.92	
		Short T		7.28 ± 1.00	7.08 ± 0.85	7.59 ± 0.93	
		Low P		8.50 ± 1.17	8.19 ± 0.85	7.87 ± 1.10	
		Low P, short T		7.64 ± 1.11	7.34 ± 0.97	7.90 ± 1.63	
TBARS	Hot-boned	Control	0.44 ± 0.14	0.52 ± 0.12	0.49 ± 0.12	0.39 ± 0.11	0.49 ± 0.27
		Short T	0.57 ± 0.17	0.50 ± 0.20	0.41 ± 0.11	0.51 ± 0.15	0.47 ± 0.10
		Low P	0.40 ± 0.03	0.37 ± 0.10	0.31 ± 0.12	0.44 ± 0.08	0.30 ± 0.09
		Low P, short T	0.26 ± 0.07	0.39 ± 0.06	0.39 ± 0.06	0.32 ± 0.06	0.32 ± 0.07
	Cold-boned	Control	0.49 ± 0.14	0.45 ± 0.06	0.46 ± 0.11	0.34 ± 0.05	0.42 ± 0.07
		Short T	0.47 ± 0.17	0.35 ± 0.12	0.38 ± 0.14	0.38 ± 0.17	0.39 ± 0.10
		Low P	0.38 ± 0.11	0.28 ± 0.18	0.28 ± 0.25	0.35 ± 0.09	0.26 ± 0.07
		Low P, short T	0.40 ± 0.17	0.38 ± 0.12	0.36 ± 0.04	0.31 ± 0.07	0.29 ± 0.08
WBSF	Hot-boned	Control	3.81 ± 0.60	3.78 ± 1.02	3.07 ± 0.95	3.28 ± 0.52	2.90 ± 0.55
		Short T	2.87 ± 0.41	2.95 ± 0.98	2.51 ± 0.36	2.99 ± 0.55	2.77 ± 0.63
		Low P	3.81 ± 0.60	3.78 ± 1.02	3.07 ± 0.95	3.28 ± 0.52	2.90 ± 0.55
		Low P, short T	4.06 ± 1.24	3.52 ± 0.74	3.78 ± 1.94	3.14 ± 1.25	3.67 ± 1.63
	Cold-boned	Control	2.83 ± 0.49	2.57 ± 0.66	2.77 ± 0.73	3.58 ± 0.76	2.03 ± 0.39
		Short T	3.48 ± 0.74	2.43 ± 0.67	3.04 ± 0.53	3.64 ± 0.72	2.96 ± 0.93
		Low P	3.73 ± 0.78	5.04 ± 0.77	3.65 ± 0.95	4.65 ± 0.66	3.26 ± 0.75
		Low P, short T	2.51 ± 0.74	3.01 ± 0.92	4.26 ± 1.41	4.26 ± 0.98	4.37 ± 2.02

Table 2. Effect of phosphate (P) level and tumbling (T) time on Hunter lightness (“L”), Hunter redness (“a”), TBARS, cook loss and Warner Bratzler shear force (mean ± standard deviation) values of cooked shoulders stored in modified atmosphere packs (70% N_2, 30% CO_2) at 4ºC.

	Carcass Side	Treatment Group	Storage time, days				
			1	7	14	21	28
‘L’	Hot-boned	Control		48.72 ± 3.23	51.52 ± 1.78	50.59 ± 4.16	
		Short T		50.69 ± 3.18	49.21 ± 2.49	50.39 ± 2.60	
		Low P		50.79 ± 4.80	50.87 ± 3.48	48.15 ± 2.65	
		Low P, short T		50.62 ± 2.18	49.90 ± 4.24	49.61 ± 1.06	
	Cold-boned	Control		57.78 ± 3.14	54.88 ± 2.91	55.73 ± 1.80	
		Short T		55.77 ± 5.57	51.52 ± 4.64	53.19 ± 6.01	
		Low P		50.76 ± 0.37	52.26 ± 5.06	52.14 ± 2.51	
		Low P, short T		52.04 ± 2.99	52.61 ± 2.43	52.93 ± 3.38	
‘a’	Hot-boned	Control		7.011 ±.43	8.25 ± 1.07	7.32 ± 1.26	
		Short T		8.98 ± 1.92	8.53 ± 1.10	9.26 ± 1.51	
		Low P		8.86 ± 1.40	8.00 ± 1.41	8.70 ± 0.76	
		Low P, short T		9.14 ± 1.01	9.18 ± 1.06	9.83 ± 1.36	
	Cold-boned	Control		7.18 ± 1.00	8.50 ± 1.62	7.88 ± 0.75	
		Short T		9.00 ± 1.09	8.98 ± 2.20	9.17 ± 1.78	
		Low P		8.95 ± 0.44	7.24 ± 0.89	7.60 ± 0.87	
		Low P, short T		8.82 ± 1.47	8.54 ± 1.41	8.70 ± 1.30	
‘b’	Hot-boned	Control		5.84 ± 0.72	6.61 ± 0.76	6.42 ± 0.82	
		Short T		6.03 ± 0.53	6.45 ± 0.63	6.47 ± 0.67	
		Low P		6.68 ± 1.26	6.60 ± 1.25	6.06 ± 0.63	
		Low P, short T		6.87 ± 0.51	7.30 ± 0.93	7.55 ± 0.28	
	Cold-boned	Control		7.31 ± 1.08	6.78 ± 0.78	7.31 ± 0.62	
		Short T		7.10 ± 0.76	7.03 ± 1.05	6.99 ± 1.14	
		Low P		6.20 ± 0.34	6.21 ± 0.61	6.01 ± 0.58	

		Low P, short T		6.72 ± 0.71	7.04 ± 0.62	7.38 ± 0.95	
TBARS		Control	0.52 ± 0.18	0.55 ± 0.10	0.62 ± 0.20	0.49 ± 0.21	0.44 ± 0.15
		Short T	0.57 ± 0.16	0.47 ± 0.22	0.42 ± 0.05	0.60 ± 0.29	0.42 ± 0.16
		Low P	0.45 ± 0.03	0.34 ± 0.31	0.28 ± 0.39	0.45 ± 0.09	032 ± 0.09
		Low P, short T	0.39 ± 0.28	0.42 ± 0.06	0.47 ± 0.15	0.34 ± 0.10	0.34 ± 0.11
	Cold-boned	Control	0.43 ± 0.25	0.57 ± 0.15	0.54 ± 0.11	0.37 ± 0.10	0.44 ± 0.13
		Short T	0.52 ± 0.15	0.48 ± 0.10	0.38 ± 0.12	0.41 ± 0.18	0.39 ± 0.09
		Low P	0.38 ± 0.04	0.33 ± 0.27	0.29 ± 0.38	0.36 ± 0.13	0.30 ± 0.09
		Low P, short T	0.30 ± 0.09	0.42 ± 0.12	0.44 ± 0.06	0.32 ± 0.06	0.35 ± 0.13
WBSF	Hot-boned	Control	3.01 ± 0.69	2.93 ± 0.42	2.86 ± 0.60	3.28 ± 0.38	3.55 ± 0.61
		Short T	3.24 ± 0.97	3.32 ± 0.95	2.97 ± 0.80	2.78 ± 0.51	3.30 ± 0.39
		Low P	2.99 ± 0.51	2.99 ± 0.82	3.77 ± 0.42	2.95 ± 0.53	2.58 ± 0.47
		Low P, short T	3.39 ± 0.31	3.19 ± 0.63	3.52 ± 0.60	3.40 ± 0.50	3.87 ± 0.80
	Cold-boned	Control	2.79 ± 0.39	2.51 ± 0.45	2.07 ± 0.33	2.35 ± 0.88	2.46 ± 0.40
		Short T	3.19 ± 0.78	3.13 ± 0.60	2.64 ± 0.24	2.45 ± 0.58	2.53 ± 0.57
		Low P	2.62 ± 0.48	2.54 ± 0.39	3.05 ± 0.14	2.95 ± 0.73	2.27 ± 0.53
		Low P, short T	3.37 ± 0.45	3.27 ± 0.96	3.31 ± 0.76	3.16 ± 0.69	3.17 ± 1.30