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A COMPARISON OF WILTSHIRE CURED PRE-RIGOR AND CONVENTIONALLY CHILLED PORK CUTS WITH ADDITIONAL CURING AGENTS

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Introduction

Pre-rigor or hot boning (HB) of meat has clear economic advantages over conventional or cold boning (CB). Losses during chilling, cost of refrigeration, labour and transportation can be considerably reduced (Pisula and Tysbury, 1996).

Wiltshire curing is a tank curing process developed in the United Kingdom over 300 years ago. Traditionally, Wiltshire curing is a lengthy process as it involves an injection, immersion and maturation stage before cooking, but results in quality products with a unique flavour.

The main functions of smoke on meat are to develop aroma, flavour and colour and also to preserve and protect from oxidation (Schwanke et al., 1996).

The use of smoke flavouring preparations offers some advantages over the traditional wood smoke. They are more economical and ecologically acceptable, they are easily applied to products and the concentration can be strictly controlled.

Rosemary contains a number of antioxidant compounds which have been shown to reduce lipid oxidation in meat (Fernandez-Lopez et al., 2005; McCarthy et al., 2001). This antioxidant activity in combination with a desirable and distinctive flavour has made rosemary the herb of choice for this study.

The present study was designed to take all of the above factors into account to produce a high quality cooked ham and cured loin with an acceptable shelf life.

Objectives

This task involved comparative analysis of Wiltshire cured pre-rigor and conventionally chilled pork primal cuts in terms of quality measurements as a function of time. Additional curing agents, rosemary oil and liquid smoke were incorporated into the hot and cold boning processes and their effects on product quality was assessed.

Methodology

Large White x Landrace pigs (n=24) were conventionally slaughtered. The leg and loin were removed from the right hand side of the carcass immediately after slaughter and

deboned. The left hand side entered the chill room (1ºC) for 24 hours, after which time, the leg and loin were also removed and the bones removed. The hot-boned and cold-boned legs and loins were Wiltshire cured. This involved brine (18% NaCl, 0.10% $NaNO_3$, 0.07% $NaNO_2$) injection (w/v 10%) followed by immersion in a cover brine (24% NaCl, 0.30% $NaNO_3$, 0.10% $NaNO_2$, at 4ºC) for 3 days and finally a maturation period where the meat was stacked and stored at 4ºC for 4 days. Liquid smoke, which was a combination of an aqueous solution of food grade carbohydrates and natural wood smoke flavours (80:20 ratio of smok-EZ MB 12: P-50) and rosemary extract in sunflower oil (Guinness Chemicals Ireland Ltd., Portlaoise, Ireland) were then applied to specified treatment groups. The meat was dipped in liquid smoke and then held to remove excess. The rosemary extract was rubbed on by hand; making sure that full coverage of the meat was achieved. The legs were placed in shrink bags (Cryovac, BB4L), vacuum packed and cooked (dry heat, internal temp. 80ºC for 8-9 hours). The loins were chilled to 0ºC (to allow ease of slicing) and then sliced. Samples of cooked hams and cured loins were stored under MAP (70% N_2, 30% CO_2) 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. Warner Bratzler shear force (tenderness) values were measured on a texture analyzer (Stable Micro Systems, UK) and results expressed in kg. 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. Cook loss was expressed as percentages of the original sample weight.

Results & Discussion

The addition of rosemary to both hot and cold boned hams resulted in greater ($p<0.01$) lipid stability over the entire 28 day storage period. Liquid smoke application also ($p<0.01$) reduced oxidation after 7 days of storage. The combination of rosemary and liquid smoke resulted in lower ($p<0.05$) TBAR values after 14, 21 and 28 days in modified atmosphere packs at 4ºC. Lipid oxidation was significantly greater ($p<0.001$) in HB and CB cured loins treated with liquid smoke after 1 and 14 days of storage. Schwanke *et al*. (1996) reported that liquid smoke at a rate of 0.2 to 0.5% in product formulation was found to have effective antioxidant properties. It contains phenol, syringol, guaiacol, catechol and eugenol, as well as acetic, propionic and other organic acids which lower pH and destroy bacterial cell walls (Pszczola, 1995). High levels (10%) have been shown to have a pro-oxidant effect (Maga, 1988), however. Rosemary extract was a successful antioxidant on loins up to 21 days of chilled storage ($p<0.05$).

Contrary to other studies (Moeller and Jensen, 1993), Warner Bratzler shear force (WBSF) values concluded that boning time did not have a significant effect on tenderness values of hams or loins. Hams treated with rosemary extract prior to cooking had lower ($p<0.01$) WBSF values after 1, 14 and 28 days of storage. Liquid smoke also had a positive effect ($p<0.05$) on tenderness up to day 14 in a retail display unit.

Cook loss was significantly greater ($p<0.05$) for CB hams which had been dipped in liquid smoke. The rosemary did not have any apparent effect on cook loss. There was a

significant difference noted between cook losses of hot and cold boned cured loins. The HB samples exhibited lower cook losses after 1 ($p<0.001$), 7 ($p<0.05$) and 21 ($p<0.05$) days of storage. The functional properties of HB meat, especially water holding and emulsifying capacities are superior to CB meat. This is due to the higher pH and level of ATP, dissociation of actomyosin and better solubility of myofibrillar proteins (Pisula and Tyburcy, 1996).

Rosemary addition had a significant effect ($p<0.05$) on lightness values of hams over the entire storage period. Cured loins treated with rosemary had greater 'L' values after 7 ($p<0.05$), 14 ($p<0.001$) and 21 ($p<0.001$) days of storage. The hams and loins treated with liquid smoke were significantly darker than the control after 14 ($p<0.001$) and 21 ($p<0.01$) days of retail storage.

The application of rosemary resulted in greater ham 'a' values after 14 ($p<0.001$) and 21 ($p<0.01$) storage days. Loins which had been dipped in liquid smoke had significantly lower 'a' values after 14 ($p<0.001$) and 21 ($p<0.01$) days of storage. CB and HB hams and loins which had been treated with rosemary extract had significantly lower 'b' values than the control group on all sampling days except on loins after 7 days of retail storage. The application of liquid smoke resulted in lower ($p<0.001$) 'b' values of hams and loins on all storage days except on hams after 7 days of retail storage at 4ºC.

Conclusions

In conclusion, a combination of liquid smoke treatment and rosemary reduced oxidation in Wiltshire cured hams over the storage period. The colour of both hams and loins was enhanced by the antioxidant effect of the rosemary extract. TBAR analysis and colour evaluation of cured loins assessed over the storage period, would suggest that variation in processing treatment did not have a consistent impact on the meat and further modification to improve the final product was necessary.

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Tables and Figures

Table 1. Effect of liquid smoke and rosemary extract on Hunter lightness ('L'), Hunter redness ('a'), Hunter yellowness ('b'), TBARS and Warner Bratzler shear force (WBSF) (mean ± standard deviation) values of Wiltshire cured 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		53.74 ± 2.93	53.51 ± 1.81	56.93 ± 2.51	
		Smoke		50.57 ± 1.47	50.61 ± 0.95	53.87 ± 1.25	
		Rosemary		57.86 ± 0.72	56.31 ± 1.97	56.73 ± 1.44	
		Rosemary, Smoke		54.75 ± 3.09	56.50 ± 2.39	56.55 ± 1.95	
	Cold-boned	Control		56.30 ± 3.68	53.47 ± 2.83	57.88 ± 4.71	
		Smoke		57.95 ± 1.72	50.12 ± 1.06	53.66 ± 0.86	
		Rosemary		56.52 ± 3.33	55.27 ± 0.21	55.79 ± 3.36	
		Rosemary, Smoke		57.44 ± 2.49	58.34 ± 2.35	58.00 ± 3.30	
"a"	Hot-boned	Control		6.08 ± 1.26	7.71 ± 0.28	7.31 ± 0.79	
		Smoke		8.05 ± 1.02	6.98 ± 0.65	7.68 ± 0.53	
		Rosemary		6.98 ± 0.90	6.99 ± 0.42	7.26 ± 1.13	
		Rosemary, Smoke		6.98 ± 1.42	5.76 ± 1.88	8.14 ± 1.96	
	Cold-boned	Control		7.26 ± 0.52	7.23 ± 1.48	7.40 ± 1.15	
		Smoke		7.51 ± 0.87	5.43 ± 0.21	7.85 ± 0.27	
		Rosemary		6.52 ± 1.86	3.6 ± 0.42	7.25 ± 1.12	
		Rosemary, Smoke		5.62 ± 0.73	5.87 ± 1.35	6.62 ± 2.45	
'b'	Hot-boned	Control		6.72 ± 1.27	7.93 ± 0.39	7.30 ± 0.65	
		Smoke		6.01 ± 0.58	5.21 ± 0.63	6.59 ± 0.61	
		Rosemary		7.52 ± 0.66	7.68 ± 0.18	6.83 ± 1.57	
		Rosemary, Smoke		7.11 ± 0.88	8.25 ± 1.42	6.22 ± 0.68	
	Cold-boned	Control		6.99 ± 1.27	7.59 ± 1.11	7.25 ± 0.96	
		Smoke		7.34 ± 0.62	6.01 ± 1.02	5.55 ± 0.49	
		Rosemary		8.29 ± 0.82	8.44 ± 0.03	7.72 ± 1.22	
		Rosemary, Smoke		8.66 ± 0.55	8.39 ± 0.87	7.94 ± 1.17	
TBARS	Hot-boned	Control	0.66 ±0.65	0.38 ± 0.15	0.31 ± 0.13	0.38 ± 0.17	0.34 ± 0.19
		Smoke	0.45 ± 0.13	0.27 ± 0.06	0.28 ± 0.11	0.23 ± 0.05	0.44 ± 0.34

		Rosemary	0.15 ± 0.05	0.20 ± 0.05	0.28 ± 0.09	0.22 ± 0.08	0.43 ± 0.26
		Rosemary, Smoke	0.34 ± 0.13	0.16 ± 0.08	0.26 ± 0.09	0.21 ± 0.04	0.13 ± 0.02
	Cold-boned	Control	0.41 ± 0.14	0.30 ± 0.08	0.30 ± 0.17	0.41 ± 0.21	0.38 ± 0.09
		Smoke	0.46 ± 0.27	0.30 ± 0.08	0.57 ± 0.15	0.27 ± 0.09	0.58 ± 0.26
		Rosemary	0.16 ± 0.07	0.23 ± 0.06	0.27 ± 0.08	0.18 ± 0.06	0.31 ± 0.15
		Rosemary, Smoke	0.35 ± 0.15	0.19 ± 0.06	0.23 ± 0.04	0.23 ± 0.04	0.18 ± 0.05
WBSF	Hot-boned	Control	5.15 ± 1.13	5.85 ± 1.81	8.40 ± 2.79	6.56 ± 0.91	4.56 ± 0.75
		Smoke	7.11 ± 2.08	5.90 ± 1.56	4.90 ± 0.82	5.76 ± 1.66	6.59 ± 1.47
		Rosemary	4.42 ± 1.11	6.61 ± 0.83	4.80 ± 0.72	5.51 ± 1.05	4.61 ± 0.79
		Rosemary, Smoke	6.07 ± 1.30	5.78 ± 1.34	4.65 ± 1.03	6.63 ± 2.54	5.47 ± 1.19
	Cold-boned	Control	7.07 ± 1.70	7.35 ± 3.28	9.53 ± 3.20	8.41 ± 2.82	5.78 ± 1.48
		Smoke	7.13 ± 1.30	5.96 ± 0.81	5.69 ± 0.98	6.23 ± 1.45	6.55 ± 1.68
		Rosemary	4.48 ± 0.92	7.24 ± 1.24	4.17 ± 1.12	5.19 ± 0.52	4.58 ± 1.01
		Rosemary, Smoke	5.55 ± 2.04	5.24 ± 1.60	4.10 ± 0.79	6.78 ± 0.95	5.66 ± 1.34

Table 2. Effect of liquid smoke and rosemary extract on Hunter lightness ('L'), Hunter redness ('a'), Hunter yellowness ('b'), TBARS, cook loss and Warner Bratzler shear force (mean ± standard deviation) values of Wiltshire cured loins 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		40.57 ± 0.38	40.65 ± 0.89	42.92 ± 1.27	
		Smoke		42.47±1.61	43.56 ± 0.25	45.17 ± 0.33	
		Rosemary		40.75 ± 1.37	39.43 ± 0.25	41.46 ± 1.45	
		Rosemary, Smoke		41.00 ± 0.95	41.06 ± 0.91	41.33 ± 1.84	
	Cold-boned	Control		43.27 ± 1.26	43.13 ± 1.66	43.64 ± 0.35	
		Smoke		43.75 ± 2.46	46.98 ± 0.55	41.52 ± 0.69	
		Rosemary		42.48 ± 1.29	43.27 ± 0.49	43.39 ± 1.07	
		Rosemary, Smoke		41.29 ± 1.99	41.94 ± 1.07	41.40 ± 2.34	
'a'	Hot-boned	Control		1.75 ± 0.61	1.31 ± 0.67	1.48 ± 0.38	
		Smoke		2.01 ± 0.49	0.99 ± 0.69	1.13 ± 0.53	
		Rosemary		1.64 ± 0.64	0.88 ± 0.48	2.47 ± 0.76	
		Rosemary, Smoke		1.66 ± 0.73	2.26 ± 0.36	2.53 ± 1.80	
	Cold-boned	Control		1.71 ± 0.91	1.80 ± 0.97	1.76 ± 0.99	
		Smoke		2.91 ± 1.03	1.39 ± 0.42	1.42 ± 0.32	
		Rosemary		1.47 ± 0.56	1.25 ± 0.29	1.91 ± 1.04	
		Rosemary, Smoke		2.15 ± 0.71	2.10 ± 0.40	3.28 ± 1.44	
'b'	Hot-boned	Control		2.85 ± 0.43	2.94 ± 0.45	3.02 ± 0.13	
		Smoke		3.63 ± 0.45	4.89 ± 0.59	4.77 ± 0.64	
		Rosemary		7.52 ± 0.66	7.68 ± 0.18	6.83 ± 1.57	
		Rosemary, Smoke		3.64 ± 0.60	3.84 ± 0.16	3.22 ± 1.05	
	Cold-boned	Control		3.09 ± 0.60	3.58 ± 0.55	3.16 ± 0.62	
		Smoke		4.30 ± 0.19	4.72 ± 0.69	5.25 ± 0.89	
		Rosemary		8.29 ± 0.82	8.44 ± 0.03	7.72 ± 1.22	
		Rosemary, Smoke		4.17 ± 0.89	4.29 ± 0.28	3.72 ± 1.09	
TBARS		Control	0.21 ± 0.05	0.21 ± 0.04	0.26 ± 0.09	0.31 ± 0.17	0.32 ± 0.20
		Smoke	0.45 ± 0.12	0.30 ± 0.07	0.58 ± 0.17	0.27 ± 0.05	0.42 ± 0.22
		Rosemary	0.08 ± 0.02	0.20 ± 0.04	0.26 ± 0.12	0.21 ± 0.09	0.39 ± 0.12
		Rosemary, Smoke	0.32 ± 0.13	0.15 ± 0.07	0.36 ± 0.11	0.25 ±0.09	0.16 ± 0.02
	Cold-boned	Control	0.23 ± 0.07	0.21 ± 0.07	0.26 ± 0.15	0.32 ± 0.19	0.24 ± 0.17
		Smoke	0.31 ± 0.05	0.25 ± 0.11	0.49 ± 0.09	0.30 ± 0.04	0.28 ± 0.07

		Rosemary	0.05 ± 0.01	0.18 ± 0.02	0.29 ± 0.13	0.17 ± 0.08	0.35 ± 0.10
		Rosemary, Smoke	0.42 ± 0.18	0.23 ± 0.12	0.25 ± 0.06	0.23 ± 0.05	0.19 ± 0.07
Cook Loss	Hot-boned	Control	22.18 ± 1.52	19.71 ± 2.70	20.82 ± 3.48	17.40 ± 3.09	20.65 ± 5.99
		Smoke	23.41 ± 3.18	22.40 ± 3.76	18.44 ± 3.60	25.40 ± 3.51	21.31 ± 4.12
		Rosemary	22.66 ± 2.16	17.32 ± 2.69	17.55 ± 2.92	17.64 ± 4.48	18.48 ± 2.94
		Rosemary, Smoke	21.92 ± 4.60	20.95 ± 2.73	20.28 ± 3.63	22.56 ± 2.67	21.89 ± 4.24
	Cold-boned	Control	25.61 ± 2.92	22.39 ± 2.79	23.17 ± 2.89	20.16 ± 3.19	20.52 ± 4.97
		Smoke	26.83 ± 3.40	24.66 ± 3.15	21.49 ± 4.65	26.30 ± 2.44	22.57 ± 3.69
		Rosemary	25.25 ± 2.31	19.80 ± 4.09	19.83 ± 2.47	18.01 ± 3.65	22.48 ± 2.82
		Rosemary, Smoke	25.69 ± 3.55	21.97 ± 3.32	21.35 ± 4.25	27.57 ± 1.56	22.79 ± 3.84
WBSF	Hot-boned	Control	5.20 ± 0.72	5.05 ± 0.88	6.66 ± 0.80	6.13 ± 1.42	4.49 ± 0.53
		Smoke	6.07 ± 1.08	5.23 ± 0.51	6.01 ± 0.97	5.26 ± 0.97	5.90 ± 1.28
		Rosemary	5.84 ± 1.30	5.10 ± 0.91	5.25 ± 0.84	5.84 ± 1.79	5.62 ± 1.36
		Rosemary, Smoke	5.56 ± 1.23	4.73 ± 0.59	5.28 ± 0.89	3.88 ± 0.39	3.97 ± 0.66
	Cold-boned	Control	5.68 ± 1.00	5.94 ± 1.08	7.27 ± 1.34	6.46 ± 2.06	5.37 ± 0.94
		Smoke	6.33 ± 1.43	5.34 ± 0.88	5.96 ± 0.77	4.62 ± 0.49	4.85 ± 0.83
		Rosemary	5.49 ± 0.70	5.79 ± 1.04	4.35 ±0.68	4.88 ± 0.79	4.66 ± 0.76
		Rosemary, Smoke	5.05 ± 0.58	4.55 ± 0.54	4.87 ± 0.52	3.71 ± 0.62	3.86 ± 0.79