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THE EFFECT OF HOT BONING AND REDUCED PHOSPHATE ON THE PROCESSING AND SENSORY PROPERTIES OF CURED BEEF PREPARED FROM TWO FOREQUARTER MUSCLES

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Background

Hot boning (HB) involves the removal of muscles or cuts before the onset of rigor mortis. It allows muscles to be treated optimally according to glycolytic behaviour patterns with the aim of producing consistent beef tenderness (West, 1983). Other advantages include reduced weight loss, reduced drip, lower capital and operating costs. A disadvantage of hot boning is that muscles disconnected from the framework of the carcass and exposed to low temperatures (chilling) and rapid pH decline are more prone to contract and toughen than muscle held in a stretched state by the carcass (Pisula & Tyburcy, 1996). The addition of phosphates to cured meat products results in improvements in water holding capacity (WHC) and binding by synergistically working with the salt to extract myofibrillar proteins. A reduction in phosphate is designed to address customer concerns about excess additives in processed food.

Objectives

The objective of this study was to examine the effect of different boning methods and phosphate levels on the quality of cured beef produced from two forequarter muscles.

Materials and Methods

Beef cuts from two forequarter muscles, M. *infraspinatus* (IS) and M. *pectoralis profundus* (PP) were hot boned within 1.5h *post mortem*. Cold boning was carried out 24h *post mortem*. Brines containing normal levels of phosphate (to give 0.3% in meat) and reduced levels of phosphate (0.15% in meat) were prepared, which resulted in a total of 4 treatments per muscle. Muscles were injected to 115% of green weight and tumbled for 2h. Tumbled muscles were enclosed in elastic netting, vacuum packed and steam cooked to a core temperature of 72 °C. Cooked samples were analysed for moisture, fat and protein content (Bostian *et al*., 1985; Sweeney & Rexford, 1987). Cook loss and yield were calculated. Texture Profile Analysis (TPA) and Warner-Bratzler Shear Force (WBSF) measurements were determined using Instron models 4464 and 5543 respectively. Sarcomere length was determined by laser diffraction as described by Cross *et al*. (1980) using a helium neon laser (Uniphase Ltd., Stevenage, Herts, UK). Mohr's method was used to determine salt content and a colourimetric molybdenum blue method

(ISO 13730) was used with a Foss FIAstar 5000 flow-rate (Ruzika *et al*. 1981) phosphate analyser (Foss Tecator AB, Sweden) to determine phosphate content. An 8 member trained panel was employed to evaluate sensory quality of sample treatments (AMSA, 1995). Results were analysed using a two-way analysis of variance (ANOVA).

Results and Discussion

Boning method (Table 1 and 2) affected yield ($P \leq 0.05$ and $P \leq 0.01$ respectively). Hot-boned IS muscles retained 3.4% less yield than cold-boned IS muscles. Similarly, hot-boned (PP) retained 3.7% less yield than cold-boned PP muscles. Boning method had an effect ($P \leq 0.05$) for cook loss in PP formed beef only giving higher losses. Previous studies showed higher yields and reduced cook losses due to hot boning (Pisula & Tyburcy, 1996; Van Laack *et al.*, 1990; Cecchi *et al*. 1988. etc.). However, West (1983) reported that advantages in moisture loss for hot-boned primals may be seen in the early stages of processing but that these advantages are often offset in later processing such as cooking. Jeremiah *et al*. (1985) found that hot-boned LD muscles had higher total cooking losses than their conventionally chilled counterparts. Phosphate level had an effect ($P \leq 0.001$ and $P \leq 0.001$ respectively) on % STPP in the final meat products for IS and PP muscles, as expected. Colour was affected by phosphate level ($P \leq 0.001$, $P \leq 0.001$ and $P \leq 0.001$ respectively) across all the colour variables (L*, a*, b*) for both IS and PP products. Samples containing normal phosphate levels were much redder (higher a* values) in colour than the reduced phosphate samples. Claus et al, (1994) state that polyphosphates contribute to colour stability. There were no significant interactions ($P \geq 0.05$) between boning method and phosphate level for cook loss, yield, STPP and colour in both products.

Phosphate level (Table 3 and 4) did not effect ($P \geq 0.05$) the sensory quality, instrumental texture and sarcomere length of both IS and PP samples. Phosphate levels affected ($P \leq 0.05$) TPA hardness and springiness for PP joints. A reduction in hardness (111.2 vs. 138.9) and springiness (5.7 vs. 6.0) would be expected at a lower phosphate level, due to reduced extraction of myofibrillar proteins (Claus *et al*. 1994). PP cold-boned products were more tender than their hot-boned counterparts. TPA results for hardness were higher ($P \leq 0.001$); Warner-Bratzler Shear Force (WBSF) were found to be higher ($P \leq 0.05$) and sarcomere length was shorter ($P \leq 0.05$) for PP products. These results are supported by the work of Cecchi *et al*. (1988), who reported that WBSF values were lower for cold-boned samples than hot-boned. However, hot-boned IS samples were rated more tender ($P \leq 0.05$) than cold-boned by taste panelists. These results were not supported by other texture measurements. TPA hardness was not affected ($P \geq 0.05$) as well as WBSF ($P \geq 0.05$). Sarcomere length contradicted taste panel results for boning method, which found hot-boned were shorter than cold-boned ($P \leq 0.001$) thus tougher. A previous study showed that the sarcomere length of hot-boned muscles were longer than that of cold-boned muscles (Nakamura *et al*. 1986). A significant interaction ($P \leq 0.001$) between boning method and phosphate level occurred in the sarcomere lengths of both IS and PP products.

Conclusions

The results indicate that hot boning did not give an expected increase in yield and reduction in cook losses in the processed products. Hot-boned joints were shown to yield tougher final products than the conventional cold-boned joints, especially in the case of PP products. Although reduced phosphate levels gave a small increase in tenderness, it had detrimental effects on binding and forming during processing and on cured colour formation. Intervention techniques such as low voltage electrical stimulation and special packaging measures may be required to reduce the toughening of the meat as well as natural binding alternatives to increase binding in low-phosphate brines.

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Table 1: Effect of boning method and phosphate level on % cook loss, % yield, % STPP and colour of cured beef (M. *infraspinatus*)

Treatment	% Cook Loss	% Yield	% STPP	L*	a*	b*
A: Boning Method						
HB	18.8	94.9	0.24	41.6	15.0	8.4
CB	16.5	98.3	0.25	42.6	15.4	8.5
SL	Ns	*	ns	ns	Ns	ns
B: Phosphate level						
0.3%	16.9	97.8	0.35	44.4	16.1	9.6
0.15%	18.5	95.4	0.14	39.8	14.3	7.3
SL	Ns	ns	***	***	***	***
Interactions A x B						
SL	Ns	ns	ns	ns	Ns	ns
Samples						
HB 0.3% Phos	17.4	96.0	0.35	44.0	15.9	9.6
HB 0.15% Phos	20.2	93.7	0.13	39.1	14.1	7.1
CB Phos	16.4	99.6	0.36	44.7	16.3	9.6
CB 0.15% Phos	16.7	97.0	0.15	40.5	14.4	7.4
SEM	0.52	0.83	0.02	0.38	0.14	0.17

SL – significance level; *, **, *** = significant at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$ respectively; ns – not significant; SEM – Standard Error of Means.

Table 2: Effect of boning method and phosphate level on % cook loss, % yield, % STPP and colour of cured beef (M. *pectoralis profundus*)

Treatment	% Cook Loss	% Yield	% STPP	L*	a*	b*
A: Boning Method						
HB	15.0	91.8	0.30	45.0	15.3	9.0
CB	12.3	95.5	0.35	46.2	15.2	9.7
SL	*	**	ns	**	Ns	ns
B: Phosphate level						
0.3%	13.7	95.4	0.41	48.0	16.2	10.1
0.15%	13.6	93.6	0.24	43.2	14.3	7.5
SL	Ns	ns	***	***	***	***
Interactions A x B						
SL	Ns	ns	ns	ns	Ns	ns
Samples						
HB 0.3% Phos	13.9	93.4	0.38	47.6	16.3	10.3
HB 0.15% Phos	16.1	90.1	0.22	42.3	14.3	7.7
CB Phos	13.3	97.5	0.45	48.5	16.2	9.9
CB 0.15% Phos	16.0	93.5	0.26	44.0	14.2	7.4
SEM	0.74	1.14	0.02	0.31	0.14	0.15

SL – significance level; *, **, *** = significant at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$ respectively; ns – not significant; SEM – Standard Error of Means.

Table 3: Effect of boning method and phosphate level on sensory quality[a], instrumental texture and sarcomere length of cured beef (M. *infraspinatus*)

Treatment	Tenderness	Overall Texture	Hardness	Springiness	Warner-Bratzler Shear Force	Sarcomere Length
A: Boning Method						
HB	6.4	4.0	77.8	5.8	15.7	2.0
CB	5.9	4.0	77.5	6.4	15.6	2.2
SL	*	ns	ns	***	Ns	***
B: Phosphate level						
0.3%	6.1	3.9	80.7	6.1	16.0	2.1
0.15%	6.2	4.1	74.7	6.1	15.3	2.1
SL	Ns	ns	ns	ns	Ns	ns
Interactions A x B						
SL	Ns	ns	ns	ns	ns	***
Samples						
HB 0.3% Phos	6.3	3.9	84.3	5.9	16.5	2.0
HB 0.15% Phos	6.4	4.1	71.4	5.7	14.9	2.0
CB Phos	5.9	3.8	77.0	6.3	15.5	2.2
CB 0.15% Phos	5.9	4.1	77.9	6.4	15.7	2.3
SEM	0.09	0.08	2.59	0.07	0.48	0.01

[a] Tenderness and overall texture were evaluated by means of eight-point scales (8 = Extremely tender/good, 7 = Very tender/good, 6 = Moderately tender/good, 5 = Slightly tender/good, 4 = Slightly tough/poor, 3 = Moderately tough/poor, 2 = Very tough/poor, 1 = Extremely tough/poor.

SL – significance level; *, **, *** = significant at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$ respectively; ns – not significant; SEM – Standard Error of Means.

Table 4: Effect of boning method and phosphate level on sensory quality[a], instrumental texture and sarcomere length of cured beef (M. *pectoralis profundus*)

Treatment	Tenderness	Overall Texture	Hardness	Springiness	Warner-Bratzler Shear Force	Sarcomere Length
A: Boning Method						
HB	4.4	3.5	144.7	5.8	30.0	2.0
CB	5.3	3.9	105.4	5.9	26.3	2.5
SL	***	**	***	ns	*	***
B: Phosphate level						
0.3%	4.9	3.7	138.9	6.0	27.7	2.2
0.15%	4.8	3.7	111.2	5.7	28.6	2.2
SL	Ns	ns	*	*	Ns	ns
Interactions A x B						
SL	Ns	ns	ns	ns	Ns	***
Samples						
HB 0.3% Phos	4.5	3.5	163.8	5.9	30.2	2.1
HB 0.15% Phos	4.3	3.5	125.5	5.7	29.3	1.9
CB Phos	5.4	3.9	114.0	6.1	25.2	2.4
CB 0.15% Phos	5.3	3.9	98.5	5.8	27.3	2.3
SEM	0.10	0.07	6.06	0.06	0.77	0.01

[a] Tenderness and overall texture were evaluated by means of eight-point scales (8 = Extremely tender/good, 7 = Very tender/good, 6 = Moderately tender/good, 5 = Slightly tender/good, 4 = Slightly tough/poor, 3 = Moderately tough/poor, 2 = Very tough/poor, 1 = Extremely tough/poor.

SL – significance level; *, **, *** = significant at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$ respectively; ns – not significant; SEM – Standard Error of Means.