MICROBIOLOGICAL QUALITY OF MINCED BEEF IN A PARTIAL HOT BONING MODEL

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INTRODUCTION

The potentials and economical benefit of hot boning and processing of beef in the pre-rigor state are well documented and have been presented in a number of reviews (Cuthbertson, 1980; Kastner, 1982; Russwurm, 1982; Pisula & Tyburcy, 1996). In Norway experience from pre-rigor boning of beef at two plants since 1986 generally confirms many of the advantages and challenges of the hot boning process. At present five plants are about to implement pre-rigor boning as part of their beef processing. Due to plant location one company has chosen to investigate a partial hot boning model which includes transportation of partially chilled carcasses for 2.5 hours between the slaughterhouse and the boning/processing plant. The cutting process was further divided in semi-hot cutting of forequarters and direct processing of ground beef, whereas hindquarters were conditioned at 14 °C before deboning. The purpose of this investigation was to bring forth documentation on the effects of this partial hot boning model regarding bacteriological quality of the end products. Derogation from the regulations in force was given for a shorter period of time by the Norwegian Food Control Authorities.

MATERIALS AND METHODS

Thirty bulls ($\bar{x}$ carcass wt. 294 kg) were conventionally dressed and eviscerated and randomly assigned to conventional chilling at 2 °C at an air speed of 0.5 m/s. The counterparts were quarted approximate 30 minutes p.m. and fore- and hindquarters were transported hanging for 2.5 hours under controlled conditions at a temperature of 12 °C. The forequarters were boned soon after arrival 6 to 9 hours p.m., while the hindquarters were further chilled at 14 °C until deboning, 20 - 23 hours p.m. All primal cuts were then chilled conventionally to a core temperature below 7 °C within 48 hours p.m. The conventionally chilled halves were quarted and transported to the deboning plant 24 hours p.m. Following transportation, the quarters were chilled further at 2 °C at an air speed of 0.5 m/s. for 24 hours, and then deboned approximately 50 hours p.m. The boning room temperature was < 12 °C and no special precautions regarding sanitary conditions were made prior to boning.

Temperature history: Carcass core (12 cm) and surface (1 cm) temperatures and air temperature 160 cm above floor level were assessed every 15 minute by a 16 channel Grant temperature logger from slaughter to boning. The temperatures of the different minced meat batches were recorded after chopping using a Kane May 42 thermometer. Minced meat batches for bacteriological testing were stored at 4 °C, and storage temperature was monitored every 15 minute by help of a Temptimen EB 853/5 SKV temperature logger.

Processing of minced meat: Beef trimmings from quarters of the different categories were minced in a 500 l Laska bowl chopper shortly after boning. While chopping, 1% NaCl and 5% water was added and the minced meat was chilled with liquid nitrogen to -2 - 0 °C. The minced meat was stuffed into 55 mm diameter plastic casings and clippsed into 18 cm chunks with a Alpina KF 630 vacuum stuffer and a Alpina clippser.

pH: The pH-value of the minced meat was assessed directly in the minced meat following the same sampling regime as for the bacteriological testing. A Knick microprocessor pH-meter, Portamess 751x with a combined glass electrode (Ingold Lot406-m6-DXK-s7/25) was used.

Bacteriological investigations: Carcass surface contamination was assessed using Petrifilm® 30 minutes p.m. of all halves (n = 60), before boning of partially chilled hindquarters (n = 30) and conventionally chilled fore- and hindquarters (n = 30). The following three sites on each side were assessed; inside of foreshank, top of back and inside of round. All samples were incubated according to NMKL 146 (30 °C; 72 hrs.). Each batch (200 kg) of minced meat from the four manufacturing meat categories were stored at 4 °C for total counts (30 °C; 72 hrs., NMKL 146), coliforms (30 °C; 72 hrs., NMKL 147) and E. coli (44 °C; 24 hrs., NMKL 125.2) at 0, 3, 6 and 8 days of storage.

Statistical analysis: The data were analysed by Tukeys test. The $\log_{10}$ transformed bacterial counts were averaged for each group and used for statistical calculations.

Table 1 Sampling plan of minced meat for bacteriological testing (n.d. = not determined).

Category		No. of batches	Days at 4 °C (no. of parallels) 0	3	6	8	Total no. of samples
Forequarters	partially chilled	8	5	3	3	3	64
	conventionally chilled	8	5	3	3	3	64
Hindquarters	partially chilled	4	5	3	3	3	32
	conventionally chilled	4	5	n.d.	n.d.	n.d.	20

RESULTS AND DISCUSSION

The core temperature in conventionally chilled hindquarters reached 7 °C approximately 28 hours after slaughter. All primal cuts and meat trimmings from partially chilled fore- and hindquarters were chilled to < 7 °C within 48 hours p.m. This is in accordance with European Council regulations in force (Directive; 88/363/EEC). The minced meat from partially chilled fore- and hindquarters was chilled to -1.0 °C at 10 and 25 hours p.m. respectively. Minced meat from conventionally chilled carcass halves reached similar temperatures (minus 0.3 °C) 52 hours p.m. The average carcass surface count after dressing and evisceration was $\log_{10}$ 1.78 (range: 0.31/2.50). Prior to cutting the surface counts were found to be $\log_{10}$ 1.59 (range: 0.56/2.38) and $\log_{10}$ 1.51 (range: 0.31/2.48) respectively for partially chilled hindquarters (24 hours p.m.) and conventionally chilled quarters (52 hours p.m.). Surface contamination levels were not significantly different ($p > 0.05$) between chilling regimes at any of many sampling times. Surface counts of conventionally chilled carcasses were significantly lower ($p < 0.05$) at the time of boning than immediately after slaughter, this is possibly due to higher surface moisture levels and temperatures immediately after slaughter, contributing to better surface contact and thus higher retrieval of bacteria by the Petrifilm® at sampling.

There were no significant ($p > 0.05$) differences in total counts between minced meat processed from partially chilled or conventionally chilled fore- and hindquarters at any sampling time (Table 2). Previous examinations of minced meat at the same plant have shown significantly lower ($p < 0.05$) total counts for partially chilled forequarters compared to those from conventional chilled forequarters. Coliform counts in minced meat from partially chilled forequarters were higher ($p < 0.05$) than that of conventionally chilled forequarters at the day of mincing (Table 3). One possible explanation for these differences could be the fact that boning of forequarters took place towards the end of a shift with no special sanitary precautions prior to boning. This as opposed to the other three categories that were boned at the beginning of a shift with all boning facilities clean at the start of the shift. For the other variants and storing times there were no significant ($p > 0.05$) differences regarding coliforms. *E. coli* was not observed (< 10 cfu/g) in any of the 276 samples of minced meat. All samples are of satisfactory microbial quality (< r) according to requirements of Nordic Committee on Food Analysis.

pH of minced meat processed from partially chilled forequarters is significantly ($p < 0.05$) higher at day of mincing than that from the other three categories (Table 4). pH measurements up to 8 days p.m. indicate that adding 1% NaCl up to 9 hours p.m. gives a partial inhibition of glycolysis. Aalhus et al (1993) reported similar effects on pH of hot boned ground meat by adding low concentrations of NaCl (1%) two hours p.m.

CONCLUSION

The present investigation does not reveal major negative effects of the partial hot boning concept on carcass hygiene and microbial quality of minced meat from partially chilled carcasses, as compared to conventionally chilled and cold boned meat. Minced meat from this alternative hot processing can be distributed and available in the stores within 24 hours of slaughter compared to up to 6 days for conventional cold boning. Improved logistics will lead to reduced bacteriological load on the carcasses at processing and thus better shelf life. The concept leads to higher water binding capacity in the minced meat produced of partially chilled forequarters due to arrest of p.m. glycolysis at an earlier stage achieved by adding of 1% NaCl.

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Table 2 Total viable count (log_{10} cfu/g) of minced meat (n.d. = not determined).

Minced meat from		days at 4 °C 0		3		6		8	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Forequarters	partially chilled	3.13	0.24	2.83	0.36	3.27	0.31	3.89	0.20
	conventionally chilled	3.18	0.29	3.05	0.37	3.30	0.32	3.98	0.43
Hindquarters	partially chilled	3.16	0.15	3.12	0.48	3.48	0.40	4.08	0.29
	conventionally chilled	3.12	0.10	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Table 3 Coliform bacteria (log_{10} cfu/g) in minced meat from the four raw material categories.

Minced meat from		days at 4 °C 0		3		6		8	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Forequarters	partially chilled	0.69	0.65	0.50	0.68	1.21	0.70	2.35	0.33
	conventionally chilled	0.08	0.26	0.59	0.67	0.98	0.72	2.13	0.63
Hindquarters	partially chilled	0.17	0.40	1.21	0.89	1.40	0.78	2.26	0.62
	conventionally chilled	0.01	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Table 4 pH-value of minced meat stored for 0, 3, 6 and 8 days at 4 °C (n.d. = not determined).

Minced meat from		day of chopping n =	$\bar{x}$	SD	days of storing 3	6	8
Fore quarters	partially chilled	14	6.04	0.05	5.92	5.99	5.98
	conventionally chilled	14	5.70	0.05	5.86	5.86	5.81
Hind quarters	partially chilled	8	5.63	0.03	5.82	5.82	5.81
	conventionally chilled	8	5.65	0.02	n.d.	n.d.	n.d.