Processing properties of hot boned beef in laboratory and full scale industrial trials

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Background

Hot boning (HB) of beef carcasses has been practised in Norway for nearly 20 years, and presently makes up 10 – 15% of the total beef production. In addition to optimum handling of primal cuts, the potential for improved processing properties and yield has been focused by the meat industry. The common HB procedure is deboning directly after slaughter. The beef trimmings are ground to 3-50 mm within 2-3 hrs post mortem (p.m.). Water and salt are added, and the meat is blended and chilled rapidly with CO_2. The pre-salted blend is used in plant or shipped to other processing plants and used within 2-4 days, for ground beef, or cooked, emulsion type products, like beef patties and sausages. Most research on the use of HB meat have been performed in laboratory scale, using single muscles or selected groups of muscles, mainly for burger type products containing only meat, salt and water. A majority of reports shows favourable effects of HB on product yield, while others have found no significant differences from that of ordinary cold boned (CB) meat *(Pisula. & Tyburcy, 1996)*. Norwegian processing plants have not been able to verify the favourable properties of HB meat in the production of emulsion type products. In order to obtain efficient logistics and reduce the risk of microbial deterioration, trimmings are rapidly chilled with CO_2, which implies partial, local freezing of the meat, causing muscle cell damage and leakage of cell fluids. Solubilised CO_2 forms carbonic acid in the muscle tissue causing a slight pH fall of approx. 0.1 units *(Daniels & al., 1985)*. The effects of CO_2 on the binding properties of HB meat are not widely documented except in the work of *Abu-Bakar & al. (1989)*.

Objective

The aim was to compare the effects of HB, pre-salted beef trimmings with those of conventional CB meat, on pH of the pre-blend and the forcemeat and the frying loss and texture of a heated emulsion type product, using trimmings produced both in small-scale experiment and under practical industrial conditions. Further, the effects of rapid CO_2 chilling on HB meat were compared with those of more slow air chilling.

Materials & methods

The experiments included conventionally slaughtered adult cattle, without deliberate selection of animal category regarding age, sex, breed or classification. The carcasses were not electrically stimulated.

Experiment 1 (laboratory scale). Meat from six carcasses, weighing between 221 and 305 kg, was used. One half of each carcass was deboned 1 hr 20 min p.m., while the other was air-chilled over night at 4°C, deboned and ground approx. 24 hrs p.m., after reaching a core temperature of 7°C. Beef trimmings with an estimated fat content of 21% ('Beef 21%') from HB halves were ground to 4 mm, approx. 30 min after boning. Within 3-5 min, salt and water were added (3 parts salt and 12 parts water per 100 parts of meat/fat). After 10 min of light blending, the meat was divided into two portions, one chilled with CO_2 to 0°C in the blender, the other in circulating air at 4°C in 10 cm thick layers wrapped in plastic.

Experiment 2 (industrial scale). Eight batches (250–400 kg) of HB beef trimmings from two slaughter days were collected after deboning approx. one hr p.m. The trimmings were sorted in two groups, according to fat content. 2-3 hrs p.m. 'Beef 21%' was ground to 3 mm, and 3-10 min later, a salt/water solution at 30°C was added at the same proportions as in Exp. 1. After 15 min of light blending, 5 kg samples from each batch were air-chilled as in Exp. 1, while the remaining meat was chilled with CO_2. The temperature at grinding was 26°C and after CO_2-chilling, between 0 and +4°C. Eight batches of CB 'Beef 21%', without added salt/water were purchased from two commercial deboning plants, ground at 3 mm and mixed with salt/water like the HB meat.

The pre-salted meat was stored at 3°C for 3-4 days prior to production of beef patties on small-scale equipment, according to recipes and procedures commonly used by industry. In Exp. 1, patties were produced after blending only, while in Exp. 2, two varieties were produced, one blended and one chopped. Batch-sizes were 2.0 kg per blender and 5.0 kg per chopper. The following recipe was used for both processes: 'Beef 21%', pre-salted HB or CB (57.5%), 'Beef 21%', unsalted CB, ground to 4 mm (13.2%), potato starch, dried milk and spices (9.3%), and ice/water (20.0%). Effective blending time was 2 min 15 sec. Final temperature in the forcemeats was adjusted to 15-18°C by adding ice/water. The blended forcemeats were chilled at 3°C over night. After forming, the patties were tempered for 20 min to 16°C, prior to frying. Effective chopping time was 4 min and final temperature was adjusted to 16-18°C by adding ice/water. These patties were made immediately. From each batch, eight 15 mm tick patties, weighing 80 ± 5 g were fried for 5 min on each side on a frying plate at 165°C, to an average core temperature of 75 ± 3°C. Patties were cooled at 20°C for 4 hrs 30 min, before being covered by plastic and left to chill at 3°C over night.

pH was recorded directly in the trimmings and in the forcemeats, using an Ingold Xerolyt gel electrode in 3-5 replicates. Frying loss was recorded after 30 min cooling. Texture was analysed at 80% compression for maximum force in a Texture Analyser type TAXT2 instrument on cylindrical samples of fried patties, 25 mm wide and 15 mm high. The effects on pH, frying loss and texture were analysed statistically, using Students T-test.

Results and discussion

In order to preserve pre-rigor binding properties, HB meat should be salted at the earliest possible time p.m., preferably before reaching a pH of 6.2 *(Hamm, 1981)*, or within 6 and 3 hrs p.m. respectively, for non-stimulated and low voltage stimulated beef *(Frøystein & al., 1984)*. Grinding may also stimulate glycolysis, thus reducing the time available for pre-rigor salting *(Hamm, 1981)*. In the small-scale experiment the process was optimised, with grinding and salt addition within 2 hrs p.m., at a pH of 6.26 (Table 1). Under practical HB conditions, 'Beef 21%' is collected and processed 2-3 times a day. In the non-optimised, industrial scale experiment, grinding took place 2-3 hrs p.m., and pH had reached 6.14 at the time of salting/blending (Table 2). To prevent further grinding and possible protein denaturation, the meat was ground directly to 3 mm. In a previous experiment, pre-rigor grinding to 4 mm caused significantly faster pH drop than to 8, 13 or 20 mm *(Røtterud, 2000)*. However, enhanced salt distribution was expected to compensate for this negative effect of fine grinding on glycolysis.

In Exp. 2, CO_2-chilling of HB pre-blends caused partial freezing, which might affect the binding properties. The significant pH lowering effect of CO_2 ($p<0.05$) observed in both experiments is in accordance with *Daniels & al. (1985)*. On the other hand, rapid chilling retards glycolysis down to 6-8°C, but also retards salt diffusion. At lower temperatures glycolysis is accelerated. No practical alternative chilling method currently exists, however, for the quantities in question. Over all, CO_2 did not seem to have a decisive effect on binding properties.

The amounts of salt and water added are similar to those used in commercial 'Beef 21%', and close to the maximum salt content that can be used without exceeding the desired salt content in final products. Salt concentrations of 2 - 4% in the HB pre-blends have been found to give optimum protein solubility and binding properties (*Hamm, 1981, Bernthal & al., 1989*). In both experiments the CB meat was pre-salted, a practice regarded as favourable *(Gumpen & Sørheim., 1987)* and widely used by the industry.

Blending and chopping are both commonly used by the industry. Chopping gave a more complete emulsification and a lower ($p<0.05$) and more uniform frying loss than blender (Table 2). This may indicate that the binding potentials of proteins in the meat are not fully exploited in the blended product. This is in line with the view that full pre-rigor emulsifying and binding properties of hot processed meat may only be realised in formulations where binding protein concentrations and qualities are marginal *(Kastner, 1982)*.

Both experiments revealed differences in pH between raw material handling. However, there is no consistent pattern in pH between pre-blends and forcemeats. This might be caused by buffering effects from other ingredients in the latter. No consistent relationship was found between pH in pre-blend and frying loss in this type of products. pH is closely related to several parameters of importance for binding properties, but evidently not a fully adequate indicator of the binding potential in pre-blends.

There is little tradition for selection of animal category for beef HB in industrial scale production. Variation in boning pattern and muscle groups included in the production meat may also influence properties like pH and protein composition and quality. This might explain the greater variation in pH and frying loss in Exp. 2.

With exception of a lower maximum compression force in patties from CO_2-chilled HB meat ($p<0.05$), no difference was observed in texture.

Conclusions

The favourable binding properties of HB beef from a small scale laboratory experiment could not be verified in patties produced from HB meat obtained in a full scale industrial trial, thus confirming practical industry experience. This can be ascribed to larger variation in raw material and processing parameters in industrial scale operation. Despite limited practical opportunities, there is need for further optimising the industrial HB process. pH does not seem to be a sufficient indicator for binding quality of processing meat.

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References

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Table 1. (Exp. 1) pH in ground trimmings ('Beef 21%') and forcemeats, and frying loss of meat patties. Mean (S.D.)

Raw material	pH in 'Beef 21%'		pH in forcemeat (blended)	Frying loss (%) (blended)
	Right after grinding	Before use (pre-salted)		
HB, CO_2-chill	6.26 (0.17)	6.07 (0.03) b	6.26 (0.04) a	7.48 (0.35) a
HB, air chill		6.14 (0.05) a	6.20 (0.01) b	6.65 (0.24) b
CB	5.95 (0.09)	5.88 (0.02) c	6.05 (0.02) c	7.75 (0.13) a

Table 2. (Exp. 2) pH in ground trimmings ('Beef 21%') and forcemeats, and frying loss and texture of meat patties. Mean (S.D.)

Raw material	pH in 'Beef 21%'		pH in forcemeat		Frying loss (%)		Texture (gram)	
	Right after grinding	Before use (pre-salted)	Blended	Chopped	Blended	Chopped	Blended	Chopped
HB, CO_2-chill	6.14 (0.10)	5.86 (0.12) b	6.06 (0.07) a	6.08 (0.09) a	6.92 (0.73) ad	5.33 (0.30) ae	7000 (456) bg	7672 (661) af
HB, air chill		6.05 (0.08) a	6.05 (0.08) a	6.06 (0.09) a	7.02 (0.83) ad	5.28 (0.14) ae	7808 (511) af	8016 (510) af
CB	-	5.72 (0.03) c	5.87 (0.06) b	5.88 (0.05) b	7.41 (0.86) ad	5.34 (0.31) ae	7755 (306) af	7591 (824) af

a, b, c Means within a column with different letters are significantly different ($p<0.05$)
d, e Means of frying loss within a row with different letters are significantly different ($p<0.05$)
f, g Means of texture within a row with different letters are significantly different ($p<0.05$)