Effect of hot boning after electrical stimulation of beef on salable meat yields and meat tenderness.

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Introduction

In the early seventies, hot boning of beef has gained considerable intrest as a potential means for slaughterhouses to reduce space and energy requirements (Henrickson, 1975).
Since then the advantages and disadvantages have been described in a number of publications (Henrickson, 1975; Cuthbertson, 1977, 1980a, 1980b; Petersen, 1980; Shaw & Bouton, 1980; Harrington, 1978; Williams, 1978; Sornay, 1980; Hamm, 1982 and Demeyer et al, 1982).
The most important advantages are the savings in space and energy as well as the reduction of weight losses during chilling which can result in a slighly higher yield of salable meat.
On the other hand early boning of beef can result in considerable toughening of the meat and requires also an important reorganisation of both slaughterhouse routine and cutting practice.
This reorganisation in most cases requires important investements which may partly explain the limited application of this technique up till now. (Cuthbertson, 1980,a,b; Harrington, 1978).
In this work meat tenderness, salable meat yield and valorisation of the meat was compared for hot boned and cold boned beef carcass halves. Preliminary results were reported by Verbeke et al. (1983).

Material and methods

Animals and treatment of carcasses: In total nineteen beef animals (mean ± SD for live weight : 598 ± 75 kg and hot dressing % : 63.0 ± 2.8%) were slaughtered in the slaughterhouse of our laboratory after captive bolt stunning and pithing. One carcass half was hot boned on the rail while the other served as control.
Of the first four animals the halves to be hot boned were not stimulated while the following were electrically stimulated immediatly after cleaving (40 to 45 min p.m.) : pulsed D.C. 700 Vpeak, pulse width 10 msec, 25 Hz (except animal 5 and 6 : 50 Hz and animal 17 : 12,5 Hz), during 2 min (except 5 and 6 : 4 min and 7 and 8 : 1,5 min) using a laboratory built apparatus (Demeyer and Vandendriessche, 1980).
Hot boning on the rail started about 50 to 65 min p.m. and was performed according to the method described by Brasington and Hammons (1971) resulting in 24 cuts.
These cuts were immediatly vacuum packed with a Komet apparatus (Stuttgart, capac. 40 m^2/h, 260 Pa) or a Stephan Alvac apparatus (Alvac typ II, Almelo, capac 63 m^3/h, vac : 50 Pa) in polyamid laminated polyethylene bags (Sidamil - X, typ EAK 41 Sidac, Ghent, permeabilities for oxygen : 135 cc/m^2/24h/20°C/50% RH and for moisture vapor 7-12 g/m^2/24h/38°C/90% RH). For each animal times of excision, temperature and pH on excision were noted for 5 different muscles : Longissimus dorsi (LD), Triceps Brachii (TB), Semimembranosus (SM), Semitendinosus (ST) and Gluteus Medius (G).
After hot boning (approx. 2,5 h p.m.) vacuum packed cuts were placed on a trolley which was moved together with the corresponding control side into the same cooler (ca 3°C).

After cooling for 7 days (first 8 animals) or 9 days (last 11 animals) the control side was boned and retail cuts were prepared from both hot boned and cold boned cuts.
At this time (respectively 8 and 10 days p.m.) Warner-Bratzler shear force values (WBS) and sarcomere lenght (SL) were determined on subsamples of 5 different muscles (LD, TB, SM, ST and G, see higher) of both sides.
Finaly the retail cuts were sold to the laboratory staff.
Yields of all different commercial cuts obtained according to the standard valorisation system used in our laboratory (Verbeke et al, 1983) and total commercial value (calculated using current prices) were obtained for both hot and cold boned halves.

Methods:

Warner-Bratzler shear force values (WBS, WB-shear mounted on an Instron model 1140, Instron LTD, High Wycombe) were determined perpendicular to the fibre direction on cock-bore samples (1.27 cm diameter) obtained from 2,5 cm thick cuts after heating (1 h immersed in a waterbath at 75°C) and subsequent cooling to room temperature (running tap water). Sarcomere lenght (SL) was determined on fresh subsamples fixed in glutaraldehyde using laser diffraction as described by Vandendriessche et al. (1984).

Results and discussion

In table 1 mean time of excission (± SD), temperature and pH of the five muscles measured for both non stimulated and stimulated animals are shown.

Table 1 : Excision time, temperature and pH at excision for 5 muscles with or without ES.

	Time at excision (min p.m.)		Temp. at excision		pH at excision	
	HB (n=3)	HB + ES (n=15)	HB (n=4)	HB + ES (n=15)	HB (n=4)	HB + ES (n=15)
LD	52 ± 16	62 ± 14	38.1 ± 0.2	38.7 ± 0.4	6.7 ± 0.2	6.3 ± 0.1
TB	67 ± 12	70 ± 16	37.0 ± 1.2	38.5 ± 0.8	6.7 ± 0.2	6.2 ± 0.1
SM	112 ± 12	111 ± 30	38.0 ± 1.2	39.2 ± 0.9	6.6 ± 0.4	6.0 ± 0.2
ST	120 ± 12	114 ± 31	36.0 ± 0.8	37.0 ± 1.5	6.6 ± 0.4	5.9 ± 0.16
G	123 ± 12	120 ± 31	37.6 ± 1.0	38.9 ± 0.8	6.4 ± 0.4	5.9 ± 0.13

mean values ± S.D.

From this table it can be deduced that temperature is ca 1°C higher and pH ca 0.55 units lower when hot boning is preceded by ES (HB + ES) compared to hot boning without stimulation.
These results are in accordance with our earlier observations (Demeyer and Vandendriessche, 1980; Demeyer et al, 1982). The time between slaughtering and packaging of the last cut is ca 2h30.

Tabel 2 : Effect of hot boning without and with ES on WBS (N) and SL (μ) of five different muscles.

	WBS ratio (HBS/CBS)		SL ratio (HBS/CBS)	
	HB (n=4)	HB + ES (n=15)	HB (n=4)	HB + ES (n = 15)
LD	1.22* ± 0.11	1.01 ± 0.09	0.98 ± 0.21	0.98 ± 0.08
TB	1.38 ± 0.29	1.23* ± 0.19	0.79 ± 0.06	0.86* ± 0.08
SM	1.20 ± 0.20	0.95 ± 1.6	0.84 ± 0.17	0.105 ± 0.14
ST	1.42 ± 0.31	1.20* ± 0.21	0.77* ± 0.12	0.92* ± 0.07
G	1.20 ± 0.26	1.13* ± 0.21	1.11 ± 0.21	0.100 ± 0.19
combined mean	1.28* ± 0.15	1.10* ± 0.07 [a]	0.89* ± 0.2	0.95* ± 0.7

HBS : hot boned side
CBS : cold boned side

* Significant difference from 1 (paired t-test, at least $p \leqslant 0.05$)
[a] Significant difference from HBS (t-test, at least $p \leqslant 0.05$)

mean values ± SD

From table 2 it is clear that hot boning without ES has a detrimal effect on tenderness (ca 30% toughening) clearly related to sarcomere shortening (10% shortening) for 3 of the five muscles. The limited number of animals (n=4) and the variability in tenderness and sarcomere lenght makes further conclusions too speculative. When hot boning is preceded by ES there is still a global toughening (10%) and shortening (5%). Because of the greater number of animals, differences between muscles can be discussed in detail. Shortening and toughening is not evenly distributed over the five muscles sampled : especially TB and ST show shortening with corresponding toughening. Gluteus medius is slightly toughened without shortening while both sarcomere length and tenderness (WBS) of LD and SM were unafected by hot boning.
The difference between the muscles sampled may be due to different responses to the electrical stimulation although according to the pH values (table 1), the effect on p.m. glycolysis was nearly identical for all five muscles. From these pH values it can be concluded that the electrical stimulation was equally effective throughout the carcass.

A possible reason for the differences may then be the difference in mechanical response of the muscles to ES. Another reason for differences between muscles is the different time of excision from the carcass. This may explain the significant thoughening of LD in case no ES has been applicated (table 2) because this muscle is removed about one hour p.m. compared to e.g. the gluteus removed about 2 hours p.m. (table 1).
From all this it can be concluded that the electrical stimulation applied was not efficient enough to avoid shortening with corresponding toughening for two of the five muscles sampled. On the other hand toughening caused by hot boning can occur in the absence of sarcomere shortening (Gluteus medius).
The negative effect of hot boning on tenderness even after electrical stimulation can probably be reduced by delayed cooling as used by Dransfield et al. (1976).

Table 3 : Meat yields and valorisation of the corresponding cold boned and hot boned carcass sides (n = 19) (mean values ± SD).

	Cold boned side	Hot boned side
Hot side weight (kg)	187.7 ± 25.8	188.3 ± 26.5
Distribution of cuts		
(% of hot side weight)		
Losses : Evaporation losses (+ drip in bag)	2.9 ± 0.6	0.9 ± 0.3*
Dissection losses (cutting/trimming)	0.18 ± 0.07	0.17 ± 0.09
Salable meat		
high price cuts : (roasts/steaks)	37.0 ± 1.7	34.5 ± 2.3*
low price cuts : - meat for stew	23.4 ± 1.3	31.9 ± 1.8
- meat for soup cooking (including bones and fat)	11.5 ± 0.5	not available
Fat trim	12.2 ± 1.6	16.7 ± 2.3*
Bone	11.6 ± 1.3	15.5 ± 1.9*
Kidney	0.3 ± 0.03	0.3 ± 0.04
Total	100	100
Commercial value		
High price (Roasts/steaks) (Bfr/kg)	104.9 ± 13.8	96.6 ± 13.8* (92 %)
Total (high price + low price) Bfr/kg)	141.8 ± 18.5	143.2 ± 18.4* (95 %)
High price (Roasts/steaks) (% of total)	74.0 ± 1.0	71.3 ± 1.6*

* at least $p \leqslant 0.05$ (paired t-test)

As there was no effect of ES on meat yield and valorisation of the meat, figures of all animals are combined for the analysis of the effect of HB.
From table 3 it is clear that evaporation losses are lower for the hot boned sides as a result of vacuum packing On the other hand evaporation can not be reduced to zero because of evaporation during cutting and handling before packing (the hot boned cuts also expose a greater surface than the whole carcass side). Drip loss in the vacuum packs has been incorporated in the evaporation losses.
The slightly positive effect on evaporation is opposed by an important reduction of the amount of meat that can be designated as suitable for roasts and steaks. Due to the cutting and packing while cuts are still warm some meat cuts are no langer suitable for use as steaks. This results in a reduced amount (ca 8% in commercial value) of high price cuts.
Another important difference is the valorisation of the low price cuts. From the cold boned side fat and bones (meat for soup cooking) are sold and this is the reason for the muscle higher bone and fat % in case of hot boning (ca 4% bone and ca 4.5 % fat are incorporated in the meat for soup cooking obtained from the cold boned side). On the other hand more meat for stew results from the hot boning and this makes the valorisation of the whole is not as negative as could be deduced from the amount of bone and fat (very low price). The overall result is a 5% loss in commercial value for the hot boned sides, practically completely caused by the reduction of the amount of wholesale cuts. A carefull study of the boning/cutting technique may result in a better valorisation of the high price cuts while on the other hand the problem of the beef for soup cooking can be resolved if only the hind quarter (and still more likeley only the pistol cut) is hot boned, while forequarters and flanks are cold boned.
So advantages of both systems are combined and disadvantages reduced to a minimum.

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