ELECTRICAL STIMULATION AND HOT BONING OF BEEF CARCASSES ASSOCIATED WITH CHILLING OR FREEZING.

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INTRODUCTION

BRAZIL freezes beef hind and forequarter during the months of March to June, to supply the demand during the dry season (August to December). In 1979 about 200,000 tons were stored. This means 35% of the frozen storage space was occupied by 60,000 tons of bones and excess fat. This material could be rendered immediately, if boning were performed before storage, avoiding cold transportation of up to 1,500 K.m. A shrinkage of 1.5 to 2.0% was observed during commercial slaughtering practices, due to carcass chilling.

The possibility of introducing hot boning in Brasil is intrinsically linked to the economic advantages, since there is no carcass grading on the basis of quality or yield.

Hot boning, followed by rapid chilling, can induce a cold shortening effect (Locker and Hagyard, 1963), causing toughening of the muscle (Locker, 1960; Marsh and Leet, 1966; Herring et al., 1965). The use of electrical stimulation to overcome this problem was studied by Carse (1973) in lamb, and more recently by Crystall and Hagyard (1976), and has been extended to beef by Davey et al. (1976), Gilbert and Davey (1976) and Bendall et al. (1976).

The potential use of electrical stimulation associated with hot boning and followed by chilling or direct freezing, could bring considerable advantages to the Brazilian meat industries.

After several tests, the Centro de Tecnologia da Carne - CTC developed a stimulator that could induce the pH decline in beef at an adequate rate to allow boning just after the dressing operation.

This study considers the possibility of using electrical stimulation associated with hot boning and followed by chilling or direct freezing of the beef in boxes. Yields, palatability and the microbiological state were studied.

MATERIALS AND METHODS

TEN Zebu cows (Nelore breed) were slaughtered, dressed and sawn into sides according to normal Brazilian commercial practices, at the Centro de Tecnologia da Carne - CTC. 30 min after bleeding, the left sides were electrically stimulated (700V, intermittent A.C., 60Hz) for 2 min with the probe inserted along the humerus bone. 45 min after bleeding the stimulated sides were hot boned and boxed (0.61x0.42x0.15cm) except for the flank (CORTE et al., 1978). The boneless cuts from five sides were chilled (2 hr after bleeding) at +2°C (open cartons) for 5 days, and the remainder were frozen in a blast freezer (2 hr after bleeding) at -40°C (until -12°C internal temperature) and stored for 3 months at -20°C.

The unstimulated right sides (control) were chilled conventionally (1 hr after bleeding) and kept at +2°C until boning was performed (36 to 40hr postmortem). The cuts from the control sides were treated identically to the paired stimulated sides.

Data on carcass traits (boneless, closely trimmed cuts, lean and fat trims, bone, boning losses and skrinkage) were collected from the control and stimulated hot boned sides. Results were analysed by the t test.

The chilling temperatures of the sides (control) and the cuts (hot boned) were monitored by thermocouple probes inserted in the geometrical center of the muscles: a) for sides - *Longissimus*, between the 11th and 12th thoracic vertebrae; and "Deep Round" a 13cm probe was inserted through the obturador foramen; b) for cuts - in the *Semimembranosus*. The freezing and thawing curves were determined on the *Semimembranosus* muscles, packed in closed cartons.

pH was determined on homogenates of samples removed 0,5, 1, 2, 4, 6, 8 and 24 hr postmortem from the *Longissimus dorsi* (LD), *Biceps femoris* (BF) and *Semimembranosus* (SM) muscles (1g meat and 10mℓ of a 5mM solution of sodium iodoacetate + 150mM potassium chloride; pH 7.0).

The WB shear force and sensory evaluations were performed on steaks (2.5cm thick) from the LD, BF and SM muscles according to CORTE et al. (1979).

Microbial counts were performed on 25g samples collected from the SM surface (frozen cuts, after thawing; chilled cuts, after 5 days), just before portioning (0 day). 2.0cm thick steaks

were displayed during 2 and 6 days at +2°C. The samples were homogeinized in sterile peptone saline water (International commission on microbiological specifications for foods, 1978) and a total plate count (plate count agar at +25°C for 3 days) performed according to Hytiainen (1975).

RESULTS AND DISCUSSION

Carcass traits

TABLE 1 shows the carcass traits from stimulated hot boned and unstimulated beef sides. The yield for boneless, closely trimmed meats was higher for hot boned than control sides. The amount of lean trim was higher for the controls than for the hot boned sides, because it is easier to clean some bones in chilled beef sides. With larges bones, such as the femur, scapula, tibia and fibula, the hot boning operation is easy to perfom, but on the clod, rib and loin bones, it is very difficult. For the whole carcass the amount of bone was bigger for hot boned than for control samples. The amount of fat trim was higher for hot boned cuts, due to difficulty in adjusting the fat cover trimming (5mm).

TABLE 1. Carcass traits from stimulated + hot boned and unstimulated beef sides.

Traits[a]	Control	Stimulated + Hot boned	t
Boneless closely trimmed meats	70.33	71.18	2.67*
Lean trim	3.20	2.59	2.68*
Bone	18.84	19.30	NS
Fat trim	5.05	6.10	4.94**
Boning losses	0.42	0.74	2.61*
Shrinkage	2.01	0.00	9.49**

[a] Expressed as a percentage of hot carcass weight; average of 10 sides.
** $P < 0.01$
* $P < 0.05$

The biggest advantage of hot bonning is lower weight losses. Even though this appears to be bigger in hot boned samples (0.74% Vs 0.42%), shrinkage is avoided, resulting in an average net gain of 1.7%.

This is incorporated primarily in the meat.

This aspect strongly encourages the use of hot boning.

Drip loss data were not collected, but a visual evaluation showed similar appearances in both cases.

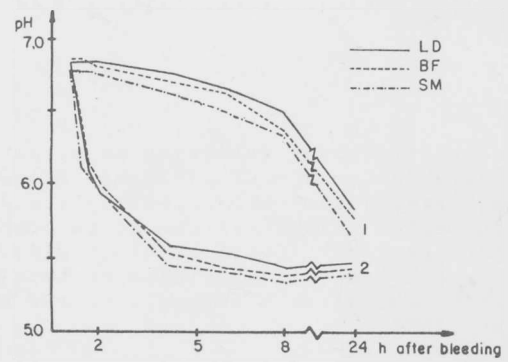

FIGURE 1. Post-mortem pH decline of LD, SM and BF muscles from (1) unstimulated chilled sides and (2) stimulated + hot boned chilled cuts.

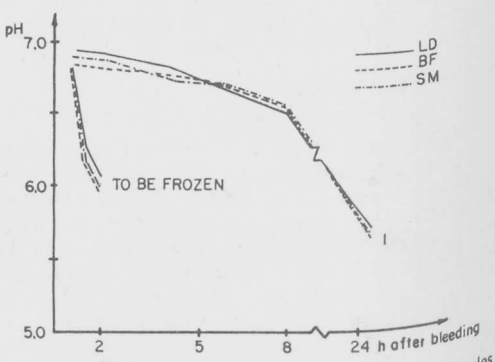

FIGURE 2. Post-mortem pH decline of LD, SM and BF muscles from stimulated + hot boned cuts (to be frozen) and unstimulated chilled sides (1).

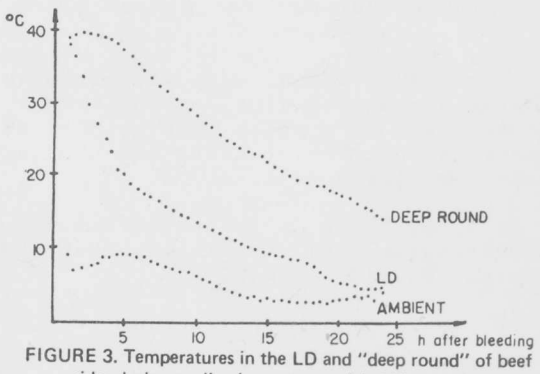

FIGURE 3. Temperatures in the LD and "deep round" of beef sides during cooling in a commercial chiller.

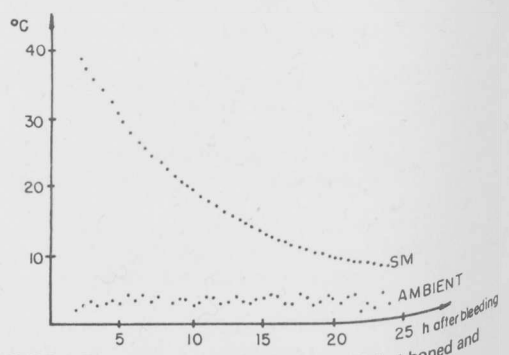

FIGURE 4. Temperatures in the SM stimulated, hot boned and boxed samples, during cooling in a commercial chiller.

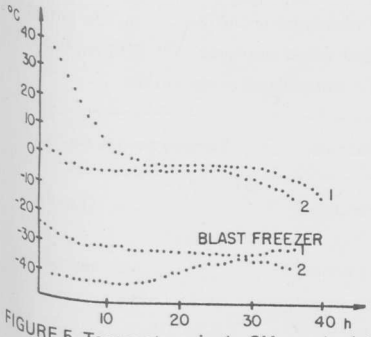

FIGURE 5. Temperatures in the SM samples (closed box), frozen in a commercial blast freezer:
(1) stimulated and hot boned;
(2) uns timulated and chilled conventionally.

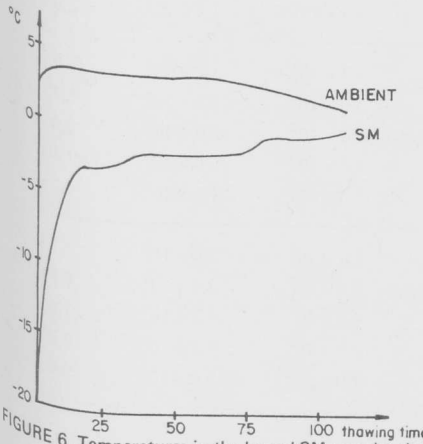

FIGURE 6. Temperatures in the boxed SM samples thawed in a commercial cold chamber.

pH and temperature decline

THE pH declines from LD, SM and BF muscles are shown in Figures 1 and 2. Rapid chilling has a serious effect on tenderness if the meat is still in the pre-rigor state, that is, before the meat pH has fallen below about 6.2.

The initial pH values (30 min after bleeding) were between 6.75 and 6.85 in both cases. In the stimulated, hot boned cuts, the muscle pH reached 6.1 to 6.2, 1.0 to 1.5 hr after bleeding. In control sides, it took more than 8 hr to reach the same pH range.

It is generally accepted that cold shortening can take place if muscles reach 10°C in less tha 10 hours (Locker and Hagyard, 1963). Figures 3, 4 and 5 show the temperature declines during chilling of cuts and sides. Cold shortening did not have a chance to occur in control sides (Figure 3) or in stimulated, hot boned and chilled cuts (Figure 4). Hot boned SM cuts from stimulated sides that were frozen in the blast freezer reached +2°C less than 10 hr after bleeding (Figure 5). But for smaller cuts such as the loin, the problem can be more critical, because SM is one of the largest muscles of the carcass. In our study we showed that cold shortening did not occur, because 2 h after bleeding, the pH was already 5.9 to 6.0.

The cuts were frozen to -12°C in 36 to 40 hr (Figure 5), and the thawing time was 108 hr (Figure 6). The final pH for the thawed cuts ranged from 5.4 to 5.5.

Meat quality

WB shear force values and palatability ratings for LD, SM and BF are shown in Table 2. LD from electrically stimulated sides for both chilled and frozen cuts were significatively more tender(WB shear force and panel test) than the controls. SM steaks from electrically stimulated sides for chilled cuts were significatively more tender (panel test) than the controls. For BF steaks there was no significant difference caused by electrical stimulation hot boning for both chilled and frozen cuts. Juiciness and flavor was not affected by electrical stimulation. As reported by Savell et. al. (1977) tenderness improvement was not uniform throughout the carcass. In the loin region (LD) there was a substancial improvement while irregular results in tenderness were observed for BF and SM muscles. Possible explanation for this could be variations in the connective tissue content of these three muscles or differences in the electrical stimuli received by each muscle.

Microbial evaluation

RESULTS of the microbiological evaluation are presented in Table 3. Chilled cuts from stimulated and hot boned sides showed initial superficial contamination about 1 log cycle than the controls (0 day). This is due to meat handling and an environment favorable to microbial growth. Thawed cuts from stimulated and hot boned sides showed a tendency to be more contaminated than the controls. Steaks displayed for 2 and 6 days after portioning, did not show differences between the treatments. This could be due to the rapid chilling rates to which the cuts were submitted.

The results showed that temperature has a bigger influence than the pH drop on the superficial microbiological growth of cuts, but not on portioned steaks.

According to the brazilian microbiological standard that accepts meat or meat products with a maximum level of 10^6 microorganisms/g, the microbiological condition of the cuts and steaks can be classified as very acceptable.

Our results showed that electrical stimulation followed by hot boning produced equal or superior meat quality with respect to palatability and microbiological condition when compared to conventional process.

As compared to conventional Brazilian practices, electrical stimulation of beef associated with hot boning shows the following economical advantages: shrinkage can be minimized; energy and space for chilling can be saved and boxed hot beef can be frozen without prior chilling.

TABLE 2. Comparison of shear force values and palatability ratings of chilled and thawed cuts from stimulated + hot boning and unstimulated (control) sides.

MUSCLE		Chilled cuts			Thawed cuts		
		Control	Stimulated + Hot boning	Fo	Control	Stimulated + Hot boning	Fo
LD	Shear force(kg)	6,3	5,1	14,1**	4,9	3,5	5,7*
	Tenderness[a]	4,4	5,9	18,7**	6,2	6,7	6,2*
	Juciness[b]	5,5	5,9	2,9	4,6	5,0	1,9
	Flavor[c]	6,3	6,1	0,5	6,5	6,4	0,6
SM	Shear force(kg)	5,8	6,4	1,2	5,9	6,5	0,5
	Tenderness	4,9	6,1	8,7*	5,2	6,0	3,0
	Juciness	6,0	5,8	0,6	4,4	4,5	0,1
	Flavor	6,4	6,3	0,3	6,4	6,3	0,1
BF	Shear force(kg)	9,6	10,9	1,0	10,7	11,4	0,5
	Tenderness	5,0	5,5	1,7	5,0	5,3	0,4
	Juciness	6,4	6,1	1,6	4,8	4,6	0,2
	Flavor	6,8	6,8	0,1	6,6	6,7	0,1

a - expressed on graphic scale, 10 = very tender; 0 = very tough.

b - expressed on graphic scale, 10 = very juicy; 0 = very dry.

c - expressed on graphic scale, 10 = very strong; 0 = very bland.

* $P < 0.05$

** $P < 0.01$

TABLE 3. Microbial counts[1] (microorganisms/g) on SM muscle samples of chilled and thawed cuts and steaks displayed at + 2°C chamber from stimulated + hot boning and unstimulated (control) sides.

Days on display	Samples from chilled cuts		Samples from thawed cuts	
	Control	Stimulated + Hot boning	Control	Stimulated + Hot boning
0 Day[2]	$3,0 \times 10^3$	$5,2 \times 10^4$	$4,3 \times 10^3$	$7,3 \times 10^3$
	$2,0 \times 10^3$	$1,0 \times 10^4$	$3,8 \times 10^4$	$2,1 \times 10^4$
	$2,0 \times 10^3$	$4,4 \times 10^4$	$2,1 \times 10^3$	$7,0 \times 10^4$
	$5,5 \times 10^2$	$5,5 \times 10^4$	$1,3 \times 10^4$	$3,4 \times 10^3$
	$1,0 \times 10^3$	$5,3 \times 10^5$	$7,1 \times 10^3$	$2,3 \times 10^4$
2 Days[3]	$7,0 \times 10^2$	$1,7 \times 10^4$	$1,2 \times 10^3$	$1,2 \times 10^3$
	$1,0 \times 10^2$	$3,0 \times 10^2$	$2,0 \times 10^2$	$5,2 \times 10^2$
	$3,0 \times 10^1$	$6,0 \times 10^2$	$2,0 \times 10^4$	$8,0 \times 10^3$
	$2,0 \times 10^2$	$4,0 \times 10^2$	$9,0 \times 10^2$	$1,4 \times 10^3$
	$2,0 \times 10^2$	$1,0 \times 10^2$	$1,8 \times 10^4$	$4,0 \times 10^3$
6 Days[3]	$3,0 \times 10^4$	$7,0 \times 10^4$	$2,8 \times 10^2$	$1,2 \times 10^3$
	$1,6 \times 10^5$	$6,5 \times 10^3$	$3,4 \times 10^3$	$8,8 \times 10^3$
	$4,0 \times 10^4$	$4,0 \times 10^3$	$4,7 \times 10^4$	$1,6 \times 10^3$
	$4,0 \times 10^2$	$2,0 \times 10^3$	$1,2 \times 10^4$	$8,2 \times 10^2$
	$1,4 \times 10^4$	$2,0 \times 10^2$	$2,6 \times 10^4$	$2,0 \times 10^6$

1. Total plate count at + 25°C for 3 days.
2. Collected on the SM surface, near the aitch bone.
3. Collected on the surface of 2.0cm thick steaks.

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