COMBINATION OF LOW VOLTAGE ELECTRICAL STIMULATION AND EARLY POST MORTEM TEMPERATURE CONDITIONING ON GLYCOLYTIC RATE AND SHEAR VALUE OF *L. DORSI* FROM *BOS INDICUS*

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Background

Hot boning of bovine meats has been extensively studied in the last decades (KASTNER, 1983; CUTHBERTSON, 1984). To prevent toughening of the meat hot boning is always associated to others processes like electrical stimulation, conditioning at high temperatures (KASTNER & RUSSEL, 1975) and ageing of the meat. In Brazil 80% of the catlle is of Nelore breed (*Bos indicus*) considered to have a tougher meat than that from *Bos taurus* (CROUSE *et al.*, 1993; WHIPPLE *et al.*, 1993). Hot boning is not used by any major slaughter plant in the country as it is feared that the meat will be tougher. Even electrical stimulation is not widely used because is not considered a reliable means of preventing toughening. The purpose of this work was to measure the effects of the combination of electrical stimulation, high temperature conditioning and ageing of cuts of *l. dorsi* on the rate of glycolysis and shear values.

Objectives

Demonstrate that hot boned *l. dorsi* from electrically stimulated *Bos indicus* carcasses can have shear values similar to those from conventionally boned meat.

Methods

Forty Nelore (*Bos indicus*) pasture-fed steers with 30-36 months of age and average slaughter weights of approximately 450 kg were slaughtered at four different occasions over a three month period. Animals were stunned and bled. The beginning of bleeding was time zero for all treatments. Low voltage electrical stimulation (LVES) with a JARVIS BV 80 stimulator [20 V (rms); 60 Hz; 0.25 amps; for 90s alternating 5s on, 5s off] was applied immediately after exsanguination. Cattle were slaughtered at the Meat Technology Centre of Institute of Food Technology in Campinas. Carcasses had an average weight of 250 kg. The animals were randomly assigned to five treatments and two replications for each slaughtering session. The *longissimus dorsi lumborum* (LD) was the muscle studied. The hot boned (HB) muscles were excised from the electrically stimulated carcasses after approximately 45 min **post mortem (p.m)** and conditioned for ten hours at 25°C (ESHB25), 15°C (ESHB15) and 0°C (ESHBO), or conventionally chilled (CC) and boned 24 h p.m. (ESCC) or not stimulated, conventionally chilled and boned 24 h p.m. (NESCC). The LD were excised between the 12th to 13th thoracic rib for remotion of the *lumborum* portion. The LD muscle were cut in three pieces of the same size (10,16cm) and all pieces were vacuum packaged in CRYOVAC® shrinkable bags and placed into 536X235X162 mm cardboard boxes. For the ESHB25 and ESHB15 treatments, after 10 hours of conditioning the pieces were moved to another storage room at 7°C until the temperature in the center of the muscle reached 10°C. Next the pieces were moved again to another storage room at 3°C and left there until the temperature in the center of the piece reached 5°C. In the final stage all pieces for all treatments were left in a storage room at 0 ±2°C for ageing up to seven and 14 days p.m.. The temperatures of the cooling rooms, carcasses and cuts were monitored and recorded in a datalogger Field Chart Novus. The **pH** and **R-Value** (A_{250}/A_{260}) determinations were made at 1, 2, 4, 6, 8, 24 hours p.m. and at 7 and 14 days p.m. and were determined according to BENDALL (1973) and HONIKEL & FISCHER (1977), respectively. **Shear forces** were determined in the 2nd, 7th and 14th days p.m. with a TA.XT2i Texture Analyzer coupled with a Warner-Bratzler probe. The steaks of LD for shear force determinations were cooked according to AMSA (1995) guidelines in an electrical grill with both plates heated till its internal temperature reached 74°C. Analysis of variance was used to test for treatment effects significance and the Tukey Test means was used to detect means differences ($p<0.05$).

Results and Discussion

In **Figure 1** are presented the post mortem temperature decline of the *l. dorsi* for all treatments. The purpose of using conditioning temperatures as high as 15° and 25° C was to simulate environment temperatures that are easily attainable in refrigerated storage rooms or transportation vehicles, conditioning at 0° was used to expose the muscle to conditions that could lead to cold shortening. The progressive chilling of hot boning cuts at 7° and 3° C were used to lower the temperature slowly as the muscles passed through rigor, reducing the chances of cold shortening occurring. For the cuts conditioned at 25° C this temperature was reached 10 h p.m. when cuts were then transferred to an storage room at 7° C where it reached 10° C after 18 h p.m. For cuts conditioned at 15°C this temperature was reached 12 p.m. whereas 10° C was reached 16 h p.m. that is six hours after the steaks were stored at 7° C. The *l. dorsi* of both treatments reached temperatures below 5° C 24 h p.m.. For the hot boned cuts conditioned at 0° C, the temperature reached 10°C after only six h p.m., the worst condition regarding chilling rates and the possibility of muscle cold shortening . The *l. dorsi* kept in the carcasses reached 10° C around 12 h p.m .. According to the empirical assumption that temperatures below 10° C should not be reached before 10 h, only the hot boned cuts conditioned at 0° C did not attend this rule, and would likely present cold shortening, as after 10 h p.m. its temperature was around 5° C.

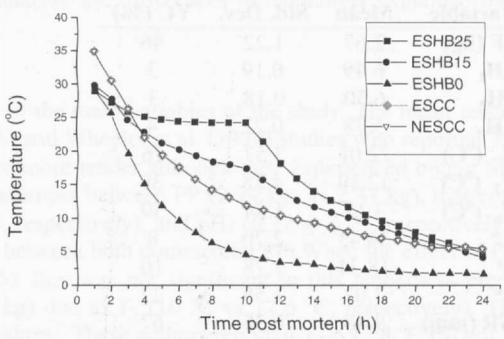

Figure 1. Post mortem temperature decline of *l. dorsi* submitted to different treatments

(ES=Electrically Stimulated animals; HB=Hot boned l.dorsi; 25, 15 or 0=conditioning at 25, 15 or 0° C; CC= Conventional Chilled; NES=Non Electrically Stimulated carcasses)

The values of pH and R value measurements in the *longissimus dorsi* from 1 to 24h post mortem are shown in **Table 1**. It has been known for a long time that the pH and temperature at which muscles enter rigor mortis has a marked influence on meat tenderness (BENDALL, 1973). When pH is above 6.2 and the muscle has enough ATP to allow muscle contractions and is temperature is below 10°C "cold shortening" will occur (BENDALL, 1978). The accelerating effect of the electrical stimulation on muscle glycolysis post mortem was confirmed: stimulated muscles reached pH 6.2 in 2-4 h post mortem whereas the non-stimulated control reached this value in 24 h. Up to 8 h post mortem stimulated muscles had pH values significantly lower ($p < 0.05$) than the non-stimulated control (NESCC). Twenty-four hours post mortem the pH of the NESCC muscles (5.91) were significantly higher than those from ESCC (5.48) and ESHB25 (5.47).

Table 1. pH decline and R-Value of *l. dorsi* submitted to different treatments

Hours post mortem	Treatments									
	ESHB25		ESHB15		ESHB0		ESCC		NESCC	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
pH										
1 h	6.34^{b}	±0.03	6.33^{b}	±0.03	6.32^{b}	±0.01	6.36^{b}	±0.01	6.82^{a}	±0.01
2 h	6.40^{ab}	±0.07	6.38^{b}	±0.01	6.23^{b}	±0.02	6.18^{b}	±0.06	6.82^{a}	±0.02
4 h	5.97^{b}	±0.09	6.17^{b}	±0.05	5.97^{b}	±0.04	6.14^{b}	±0.03	6.68^{a}	±0.01
6 h	5.71^{b}	±0.06	5.85^{b}	±0.11	6.01^{b}	±0.03	5.93^{b}	±0.02	6.59^{a}	±0.01
8 h	5.64^{b}	±0.08	5.69^{b}	±0.05	5.91^{b}	±0.03	5.75^{b}	±0.09	6.55^{a}	±0.00
24 h	5.47^{b}	±0.01	5.59^{ab}	±0.08	5.73^{ab}	±0.02	5.48^{b}	±0.04	5.91^{a}	±0.02
R-Value										
1 h	0.965^{ab}	±0.03	0.964^{ab}	±0.03	1.007^{a}	±0.02	0.887^{ab}	±0.04	0.855^{b}	±0.03
2 h	0.980^{ab}	±0.06	0.945^{ab}	±0.04	1.034^{a}	±0.04	0.955^{ab}	±0.03	0.851^{b}	±0.01
4 h	1.010^{ab}	±0.04	1.050^{a}	±0.07	1.099^{a}	±0.05	0.972^{ab}	±0.03	0.831^{b}	±0.02
6 h	1.215^{a}	±0.08	1.124^{a}	±0.06	1.230^{a}	±0.06	1.071^{ab}	±0.04	0.886^{b}	±0.04
8 h	1.217^{a}	±0.08	1.226^{a}	±0.03	1.299^{a}	±0.06	1.114^{a}	±0.06	0.855^{b}	±0.03
24 h	1.394^{a}	±0.09	1.386^{a}	±0.03	1.410^{a}	±0.02	1.445^{a}	±0.09	1.262^{b}	±0.06

SE=Standard Error of Means, n=8 replications for treatments; Same superscrit letters in the same row indicate no significative difference by Tukey test ($p < 0.05$)

The R values are shown on **Table 1**. Up to two hours p.m. only the ESHB0 had R values significantly higher ($p < 0.05$) than the NESCC. Four hours p.m. the treatments ESHB0 and ESHB15 had R values larger than NSCC. Six hours p.m. all hot boning treatments (ESHB25, ESHB15, ESHB0) had R values significantly larger ($p < 0.05$) than NESCC. Eight hours p.m. all treatments with electrical stimulation had R Values significantly larger ($p < 0.05$) than the NESCC. Twenty-fours hours p.m. the situation remained the same. These results would indicate that at lower temperatures electrically stimulated muscles were not affected by the conditioning temperature.

In **Table 2** are presented the shear force values of the *l. dorsi* at 2nd, 7th and 14th day post mortem for all treatments. With the ones of other authors as higher cooking temperatures toughnens the meat.

Table 2. Shear force values of *l. dorsi* submitted to different post mortem treatments

Shear Force (kgf)*	Treatments									
	ESHB25		ESHB15		ESHB0		ESCC		NESCC	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
2 days p.m.	5.64^{b}	± 0.29	6.62^{ab}	± 0.23	7.41^{a}	± 0.50	6.81^{ab}	± 0.49	6.68^{ab}	± 0.51
7 days p.m.	4.85^{b}	± 0.28	5.23^{ab}	± 0.37	5.79^{ab}	± 0.37	5.34^{ab}	± 0.36	6.69^{a}	± 0.65
14days p.m.	4.30	± 0.42	4.59	± 0.35	5.11	± 0.33	4.81	± 0.50	6.01	± 0.61

SE=Standard Error of Means, n=8 replications for treatments; Same superscrit letters in the same row indicate no significative difference by Tukey test ($p < 0.05$)

The values obtained 2 days post mortem should reflect more clearly the effects of the different treatments due to the fact that ageing would be in its early stages. Conditioning at 0° C resulted in meat with significantly higher shear forces ($p<0.05$) than those from steaks conditioned at 25° C. However at this stage the shear force values of the meat from both treatments did not differ statistically ($p > 0.05$) from all other treatments. After 7 days of storage at 0 ± 2° C only the steaks from non-stimulated carcasses (NESCC) had higher shear force values than the steaks from the ESHB25 treatment. After 14 days of storage no differences ($p > 0.05$) in shear values were observed among treatments.

Conclusions

1) Only electrically stimulated hot boned cuts conditioned at 0° C might have been subjected to cold shortening as shown by higher shear values at 2 days p.m. but ageing for seven days supressed this effect.

2) For the electrically stimulated muscles the rate of pH fall was not affected by the temperature of conditioning.

3) Ageing the meat for 14 days resulted in meat of similar shear force values irrespective of electrical stimulation and temperature of conditioning.

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