EFFECTS OF ELECTRICAL STIMULATION AND STORAGE TEMPERATURE ON SHEAR VALUES, TENDERNESS AND JUICENESS OF L. DORSI

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Background
Nowadays the most used ageing technique to improve meat tenderness is to keep the vacuum packed meat for a period of time at refrigeration temperatures. However, the prescribed conditions of time and temperature for maximum tenderness vary according to different authors (LANARI *et al.*, 1987; JONES *et al.*, 1991;MITCHELL *et al.*, 1991). It seems, at least in Brazil, that conditions used by industry has been selected empirically.
Although electrical stimulation is used primarily to prevent cold shortening of the meat in the carcasses, several authors (POWELL, 1991; SHORTHOSE, 1996; PUGA, 1998) have indicated a significant beneficial effect of electrical stimulation on meat tenderness.
The purpose of this work was to determine the effect of electrical stimulation and of two temperatures ranges of storage on objective and subjective measurements of tenderness.

Objective
To establish the influence of electrical stimulation and refrigeration temperature on ageing time of *L. dorsi* from *Bos indicus*.

Material and Methods
Animals: Eleven *Bos indicus* cows (36-48 months of age), six of Guzerá breed and five Nelore, were slaughtered at the Centro de Tecnologia de Carnes – CTC abattoir. The animals were stunned with a captive bolt and shackled by the hindleg. Forty five minutes after bleeding the half carcasses, selected according to a randomizing table, were electrically stimulated at 220V, 0,5A for 1½ min. All half carcasses, stimulated or not, were stored for 24h at 5°C before deboning and separation of the *L. dorsi* cuts. Each *L. dorsi* was sectioned in half, generating 44 experimental units of which 32 were randomly distributed between the two storage temperatures.
Ageing: Each *L. dorsi* cut was vaccum packed in Viskake Perflex® bags and submitted to thermal shrinkage in water kept at 90° ± 1° C for 1-2s. After packaging the cuts were randomly distributed in two storage chambers kept at 0 - 2°C and 6 - 8°C and stored up to 21 days, with samples being colleted at 7, 14 and 21 days. After each time of storage the samples were frozen in a nitrogen freezing chamber at -40°C for 1h and them stored for two weeks at -18°C.

Methods: pH- The pH of the *L. dorsi* was measured in intervals of 1h during the first 6 h post mortem using the iodoacetate technique (BENDALL, 1973); **Shear force-** It was followed the procedure of SHACKLEFORD *et al.* (1991) adapted to the conditions of the experiment. Two slices of 2 cm of width were sawed from each frozen *L. dorsi* piece, and thawed for 24h at 2°C. Each slice was cooked in a hot plate at 200°C, cooked up to 40°C, turned over, and left cooking until its internal temperature reached 70 ± 2°C. From each beef slice were taken 12 cylinders of 0,5 inch of diameter that had its shear value determined by means of an Instron couple with a Warner-Bratzler blade; **Sensory Analysis-** consisted in the evaluation of tenderness and juiciness by a trained panel of 10 members, using a computerized system Compusense Inc. version 4.2 (CSA, 1992); **Statistical Analysis-** the variables studied were submitted to analysis of variance (ANOVA) and the averages compared using LSD at 5% level by means of "Statistica for Windows" version 5.0.

Results and discussion
pH change: The pH drop of the *L. dorsi* muscle as expected, was faster for the electrically stimulated muscles reaching a pH=6.0 six hours post mortem as shown in Figure 1. MARSH *et al.* (1988) suggested that the muscle pH 3 h post mortem should be in the range 6.0 – 6.1 to assure that the resulting meat will be tender. As seen in Figure 1 after 4h post mortem the *L. dorsi* of the stimulated half carcasses reach a pH=6.1 while the non stimulated had pH=6.4.
Shear values: There was a significant difference ($p < 0.05$; $F= 10.24$) between shear values of stimulated versus non stimulated samples. The meat for stimulated carcasses reached minimum shear values after only 7 days of storage while the non stimulated took 14 – 21 days to reach similar values. These results agree with those of HOPKINSON *et al.* (1985) and POWELL (1991). After 21 days of storage there was no significant difference between the shear force of cuts for both treatments, as aging time had a significant effect in lowering shear values for both eletrically stimulated ($p < 0.05$; $F=12.74$) and non stimulated samples ($p < 0.05$; $F=9.19$).
The two ranges of sorage temperatures had no significant influence on shear values for stimulated ($p > 0.05$; $F=0.14$) and non stimulated samples ($p > 0.05$; $F=4.06$), although shear values tended to be lower for the upper temperature range.
Tenderness & juiceness: In the cuts from stimulated carcasses only ageing time had a significant influence on tenderness scores ($p < 0.05$; $F=3.57$) while for those from non stimulated carcasses aging time ($p < 0.05$; $F=4.79$) and temperature ($p < 0.05$; $F=15.81$) significantly affected the tenderness scores. It should be pointed out that while shear values where lower for stimulated samples stored at the two temperatures ranges (Table 1) panelists gave higher scores for non stimulated samples stored upper temperature range (6 - 8°C) (Table 2). The juiceness evaluation (Table 2) did not help to clarify these differences between shear values and tenderness scores: there was no influence of aging time ($p > 0.05$; $F=0.42$) or storage temperature ($p > 0.05$; $F=2.70$) on juiceness scores for stimulated samples. The same was found for non stimulated samples: nor aging time ($p > 0.05$; $F=1.94$) nor storage temperature ($p > 0.05$; $F=0.01$) influenced juiceness scores. It should be considered that the standard deviation values of the scores for both tenderness and juiceness were quite high suggesting large variation among the panelist scores.

Conclusions

- Electrical stimulation accelerated the development of tenderness during ageing of *L. dorsi* vaccum packed;
- Ageing time had a significant effect on improving tenderness;
- Ageing at 0 – 2°C or at 6 - 8°C did not significantly affect tenderness.

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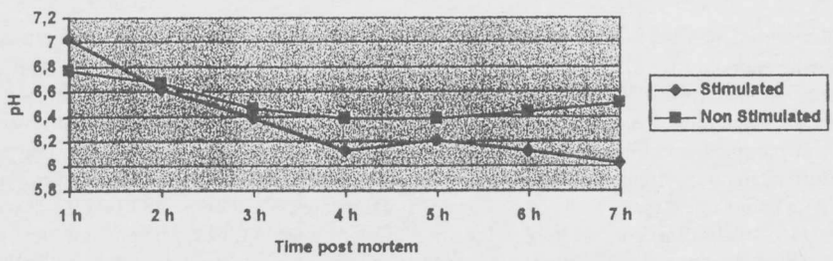

Figure 1. Post mortem pH drop of *L. dorsi*

Table 1. Effects of electrical stimulation, time and storage temperature on shear values[1] of *L. dorsi*

Time	0 – 2 ° C				6 - 8° C			
(d)	S	sd	NS	sd	S	sd	NS	sd
0	5.60	0.53	5.60	0.53	5.60	0.53	5.60	0.53
7	4.20	0.56	5.60	0.00	4.05	0.07	5.00	0.56
14	3.63	0.61	4.87	1.04	3.73	0.45	4.37	0.61
21	4.07	0.40	4.07	0.38	3.73	1.00	4.17	0.38

S: electrically stimulated; **NS:** non stimulated
1 kg/g

Table 2. Effects of electrical stimulation, time and storage temperature on tenderness[1] and juiceness scores[2] of *L dorsi*

Time	0 – 2 ° C				6 - 8° C			
(d)	S	sd	NS	sd	S	sd	NS	sd
7 [1]	6.64	0.89	5.85	0.95	7.07	1.19	6.02	2.01
7 [2]	*7.00*	*0.61*	*6.72*	*0.36*	*6.40*	*1.23*	*6.52*	*1.66*
14 [1]	6.24	1.19	5.45	1.54	6.08	1.26	7.86	0.77
14 [2]	*6.66*	*1.27*	*7.35*	*0.36*	*5.87*	*1.64*	*7.38*	*0.99*
21 [1]	7.02	0.68	5.94	1.70	7.33	0.82	7.61	0.80
21 [2]	*6.74*	*1.03*	*5.70*	*1.94*	*6.24*	*1.45*	*6.55*	*1.81*

S: electrically stimulated; **NS:** non stimulated
[1] **Tenderness** (0=hard; 10=extremely tender)
[2] ***Juiceness*** *(0= dry; 10=juicy)*