EFFECTS OF ELECTRICAL STIMULATION ON MUSCLE *PSOAS MAJOR* FROM *BOS INDICUS* CARCASSES SUSPENDED BY THE AITCH BONE OR CHILLED VERY FAST AFTER HOT BONING

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Background

Tenderness is a measure, for the consumer, of the quality of beef and other meat. There are some techniques to improve meat tenderness that are applied before, during and after slaughter. HOSTETLER et al. (1972) studied several forms of hanging pre-rigor carcasses and their results showed an improvement of tenderness in unaged beef. Several other authors NORMAN & CIA (1980), JEREMIAH (1984), HOSTETLER (1973), (1975), (1976), JOSEPH (1977) and AALHUS et al. (1999) studied the procedures of hanging the carcasses, but without electrical stimulation, and they found that the muscle *Psoas major* always became tougher with reduced sarcomere length. In other way it is important to accelerate the production of meat and so, the use of some techniques is of utmost importance. The hot boning is one of them and several studies have been done showing its economical advantages and enhancement of the functional properties of the meat (KASTNER, 1977 and 1983, CUTHBERTSON, 1984). In Europe recently, an alternative hot boned chilling practice known as ultra rapid chilling has been investigated for beef (JOSEPH, 1996; O'MAHONY, 1997) and lamb (REDMOND, 2000) carcass processing. Results from some studies indicate that there are minimal differences in tenderness between ultra fast and conventionally chilled products but other studies demonstrated that its commercial application would seem somewhat limited.

Objectives

1). To verify how low voltage electrical stimulation and the time that carcasses stay hanged by the aitch bone affect quality parameters and attributes of muscle *Psoas major* from *Bos indicus* animals. 2). To compare the effects of very fast chilled hot boned meat to traditionally chilled boned muscle on quality parameters and attributes of muscle *Psoas major*.3) To evaluate the effect of ageing on treatments studied.

Materials and methods

Forty Nelore (*Bos indicus*) forage-feed steers with 30-36 months of age were slaughtered at four different times over a period of three months. The electrical stimulus was applied to all treatments immediately after exsanguination with low voltage electrical stimulator (LVES) JARVIS BV 80. The experiment involved two treatments for the hot boned (HB) muscle *P. major* (PMA). The PMA of the left carcass sides were hot boned at approximately 45 min post mortem (PM), and vacuum packed in barrier bags. The first HB treatment consisted in submitting immediately the packed cuts to 0ºC and conditioning it for 14 days (HB0). The second HB treatment was to chill the cuts very fast after boning using an air freezer tunnel (–20ºC, 2m/s) (HBVFC) that lasted 3h PM until the muscle surface temperature reached –1 or –2ºC. The other three treatments carcasses were conventionally chilled and hanged by the Achilles tendon or were suspended by the pelvis for different periods of time, 10h PM in one treatment (PS10) and 20h PM in the other (PS20). The carcasses suspended by the Achilles tendon and conventionally chilled at 0ºC (AT) were the controls. The PMA boned after 24h PM were vacuum packed and conditioned at 0ºC for 14 days. The pH was determined at 1, 2, 4, 6, 8, 24 hours PM (KASTNER et al. 1993) and at 7 and 14 days PM utilizing the methodology described by BENDALL, 1973. For determination of R-Values (A 250/A 260), the same samples for the pH were used. It was determined with a spectrophotometer VARIAN Cary 1E according to HONIKEL & FISCHER (1977).

Sarcomere length was measured utilizing a general protocol of histological processing for morphometric analysis of length. The images was captured with microscope (Eclipse 800 Nikon Japan), digital camera (CoolSnap-Pro Digital Media Cybernetics USA) and processed with the ImagePro-Plus Software Media Cybernetics USA.

Three 2.54cm PMA slices per treatment were cooked at 2nd, 7th and 14th days PM for shear force determinations. The steaks of PMA were cooked according to AMSA (1995) guidelines in an electrical grill (150ºC) till its internal temperature reached 74°C. The steaks of PMA were weighed before and after cooking for determining the total cooking loss. Temperatures were monitored using digital thermometer NOVUS 51 with (K type) probe inserted into the center of each steak. Dripping loss was measured at 2, 7 and 14 days PM weighing the meat packs before and after opening it. Shear forces were determined with a TA.XT2i Texture Analyzer coupled with a Warner-Bratzler probe (TA-7 USDA)Tenderness was evaluated by 15 trained panelists utilizing a structured scale with 10 cm where 0 was slightly tender 5 tender and 10 very much tender and statistically analyzed as incomplete balanced blocks (Compusense Inc 4.2). Analysis of variance was used to test for treatment effects significance and the Duncan Test means was used to detect means differences ($p<0.05$).

Results and discussion

pH drop – pH values from HBVFC treatment, (pH_8=5,80 e pH_{24}=5,63) were higher than other treatments ($p<0.05$) at 8 and 24 hours (AT pH_8=5,59 e pH_{24}=5,46; HBO pH_8=5,54 e pH_{24}=5,53; PS10 pH_8=5,61 e pH_{24}=5,46; PS20 pH_8=5,62 e pH_{24}=5,52) and it seems that fast chilling stopped the pH decline. **R values** were high at first hour PM, ranging from 1,22 to 1,31, with no significant differences among treatments ($p>0.05$), showing a high conversion of ATP.

As shown in Table 1 the HBVFC muscles showed significantly greater dripping loss at the 2nd day PM than the conventionally chilled boned meat but not in relation to the HB0. There were no significant differences ($p>0.05$) between treatments in seven days PM but at the 14th day PM the HBVFC muscles presented the highest dripping losses and the control (AT) the lowest ($p<0.05$). There were no significant differences in cooking losses ($p>0.05$) comparing all treatments, even during aging period. JOSEPH & CONNOLY (1977) found similar results to the cooking losses.

In contrast to HOSTETLER (1972), NORMAN & CIA (1980), HOSTETLER (1973), (1975), (1976), JOSEPH (1977) our results presented in the Table 3 shows that the Warner-Bratzler shear force values of the HBVFC muscles showed no significant difference in relation to the other treatments, except for the HB0 muscles at 14th day PM that showed lower shear force values than PS10 ($p<0.05$). JEREMIAH (1984) didn't find any significant difference in PMA shear forces and tenderness until 144 hours PM. It seems that electrical stimulation diminishes the differences founded in shear force of muscles obtained from carcasses not electrically stimulated. The tenderizing effect of aging was observed only in the HBO and AT treatments.

Tenderness scores for HBVFC muscles showed that they were tougher than AT muscles at the 2nd and 14th day PM ($p<0.05$) but not in relation to other treatments. Ageing increased significantly the tenderness of muscles from AT and EQ0 treatments ($p<0.05$). It is clear that there was no significant difference between the chilled boning treatment with pelvic or Achilles tendon hanging. This is in disagreement with the authors cited above, confirming that electrical stimulation could be the reason for this behavior.

In Table 4, we can see that there is no difference of sarcomere length at boning time for all treatments, but at the 14th day PM only the sarcomeres of treatment PS10 were significantly shorter ($p<0.05$). It seems that the HBVFC treatment didn't promote a cold shortening effect. There is no explanation why only the PS10 treatment caused a shorter sarcomere at 14th day PM, but this is in accordance with previous works. Although the sarcomere became shorter, its effect was not evident in tenderness scores and shear force values.

Conclusions

The electrical stimulation promote no differences in shear values and tenderness scores for *Psoas major* from carcasses suspended by pelvis or by Achilles tendon.

The results showed that HBVFC doesn't toughens vacuum packed beef muscle *P. major*

Table 1. Means and standard errors for dripping and cooking losses of muscle *Psoas major*, of different treatments at 2, 7 and 14 days PM.

Measurements	Treatments									
	HBO		HBVFC		PS20		PS10		AT	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Dripping losses										
2 days PM	1.05^{ab}	±0.12	$1.22^{a;z}$	±0.36	$0.65^{bc;y}$	±0.04	$0.68^{bc;y}$	±0.08	0.42^{c}	±0.03
7 days PM	1.68	±0.49	2.21^{y}	±0.27	1.29^{x}	±0.25	1.68^{x}	±0.32	1.70	±1.05
14days PM	1.71^{bc}	±0.22	$3.46^{a;x}$	±0.37	$1.30^{bc;x}$	±0.12	$1.80^{b;x}$	±0.43	0.98^{c}	±0.12
Cooking losses										
2 days PM	26.92	±1.38	28.85	±1.16	28.29	±2.03	28.25	±0.57	28.05	±1.37
7 days PM	28.25	±0.75	32.01	±2.41	30.15	±1.66	29.50	±0.50	28.49	±0.86
14days PM	29.36	±0.59	27.70	±0.79	30.13	±1.64	28.26	±1.20	29.75	±0.60

a,b,c Treatment effect. Means in the same line with different superscripts are different $p< 0.05$; x,y,z Ageing effect. Means in the same column with unlike superscripts are different $p< 0.05$. HB=Hot Boned; 0=conditioning at 0°C;VFC=Very Fast Chilling;PS=Pelvic Suspension;10 or 20=pelvic hanging hours; AT-Achilles Tendon

Table 2. Means and standard errors for shear force and tenderness scores for muscle *P. major* of different treatments at 2, 7 and 14 days PM

Measurements	Treatments									
	HBO		HBVFC		PS20		PS10		AT	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Shear force (kgf)										
2 days PM	4.34	±0.35	4.56	±0.24	4.42	±0.21	4.65	±0.29	4.32	±0.17
7 days PM	4.20	±0.22	4.20	±0.13	4.64	±0.30	4.32	±0.21	4.28	±0.26
14 days PM	3.70^{b}	±0.15	4.17^{ab}	±0.22	4.04^{ab}	±0.25	4.54^{a}	±0.27	4.37^{ab}	±0.18
Tenderness[1]										
2 days PM	$7.73^{ab;y}$	±0.22	7.69^{b}	±0.33	7.90^{ab}	±0.16	7.80^{ab}	±0.25	$8.43^{a;y}$	±0.10
7 days PM	7.93^{xy}	±0.23	7.75	±0.30	7.88	±0.21	7.91	±0.23	8.31^{y}	±0.13
14 days PM	$8.29^{ab;x}$	±0.25	8.08^{b}	±0.28	8.25^{ab}	±0.12	8.23^{ab}	±0.24	$8.84^{a;x}$	±0.06

a,b,c Treatment effect. Means in the same line with unlike superscripts are different $p< 0.05$. x,y,z Ageing effect. Means in the same column with unlike superscripts are different $p< 0.05$. HB=Hot Boned; 0=conditioning at 0°C;VFC=Very Fast Chilling;PS=Pelvic Suspension;10 or 20=pelvic hanging hours; AT-Achilles Tendon; [1] Structured scale with 10 cm where 0 was slightly tender 5 tender and 10 very much tender.

Table 3. Means and standard errors for sarcomere lenght (SL) (μm) of muscle *P. major* of different treatments at boning and at 14 days PM

Measurements	Treatments									
	HBO		HBVFC		PS20		PS10		AT	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Deboning	2.794^{a}	0.0732	$*2.45^{a}$	0.148	2.68^{a}	0.092	2.424^{a}	0.22	2.95^{a}	0.206
14 days PM	2.824^{ab}	0.34	2.524^{ab}	0.194	2.938^{a}	0.134	2.248^{b}	0.088	3.122^{a}	0.154

* After very fast chilling. a, b Treatment effect. Means in the same line with unlike superscripts are different $p< 0.05$
HB=Hot Boned; 0=conditioning at 0°C;VFC=Very Fast Chilling;PS=Pelvic Suspension;10 or 20=pelvic hanging hours; AT-Achilles Tendon

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Acknowledgements: This project was done with the financial support of FAPESP