VERY FAST CHILLING AND QUALITY PARAMETERS OF MUSCLE *L. DORSI* FROM *BOS INDICUS* NELORE STEER

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Introduction

Tenderness is one of the most important properties of meat to the consumer. The bos indicus breed, largely produced in Brazil, gives a tougher meat when compared to European breeds. The hot boning is a well established process to accelerate meat processing and several studies have been done showing its economical advantages and enhancement of the functional properties of the meat (KASTNER, 1977, CUTHBERTSON, 1984). Until now no meat company adopted this kind of boning in Brazil. In Europe recently, an alternative 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

The purpose of this study was to investigate the effects of very fast chilling and aging of electrically stimulated hot boned cuts on quality parameters and sarcomere length of Longissimus dorsi muscle from bos indicus Nelore steers.

Methodology

Twenty four forage fed Nelore steers with 30-36 months of age were slaughtered at 4 different times over a period of 3 months. The animals were randomly assigned to 3 treatments and 2 replications for session. In all treatments low voltage electrical stimulation (JARVIS BV 80) was applied immediately after bleeding. The L. dorsi (LD) muscles were excised at approximately 45 min post mortem (PM). The muscles of the right side of carcasses were chilled very fast in a tunnel freezer with forced air circulating at 2m/s and –20ºC (HBVFC). The cooling time lasted, in average, 2h and 30 min until the muscle surface reached –1 or –2ºC. Temperatures near the surface and at the center of muscle were measured with T type thermocouples and recorded in a Grant Datalogger. After chilling muscles were divided into 3 pieces and vacuum repacked. The muscles of the left side of carcasses were also divided into 3 pieces, vacuum packed in barrier bags and stored at 0ºC up to 14 days (HB0). In the control treatment the boned muscles from

carcasses hanged by the Achilles tendon were conventionally chilled 24h at 0ºC (AT). Muscles were also divided into 3 pieces, vacuum packed and conditioned at 0ºC for 14 days. The meat pieces were randomly taken for analysis at 2, 7 and 14 days PM The temperatures of the cooling rooms, carcasses and cuts were recorded in a datalogger Field Chart Novus.

The pH and R values were sampled at 1, 2, 4, 6, 8, 24 hours PM and at 7 and 14 days PM. pH was determined as described by BENDALL, 1973 and R-Values (A 250/A 260), according to HONIKEL & FISCHER (1977) with a spectrophotometer VARIAN Cary 1E.

The meat pieces were cut into three 2.54cm slices for shear force determinations and sensory analysis at 2nd, 7th and 14th days PM. The steaks were cooked according to AMSA (1995) guidelines in an electrical grill (150ºC) till its internal temperature reached 74°C. Total cooking losses were calculated weighting steaks before and after cooking. Temperatures in the center of steaks were monitored with digital thermometer NOVUS 51. Shear forces were determined with a TA.XT2i Texture Analyzer with a Warner-Bratzler probe (TA-7 USDA).

Tenderness, juiciness and flavor were evaluated by 15 trained panelists utilizing structured scales with 10 cm, where 0 meant slightly tender or slightly juicy or slightly aged flavor, 5 meant tender or juicy or aged flavor and 10 meant very much tender or very much juicy or intense aged flavor. It was statistically analyzed as an incomplete balanced blocks (Compusense Inc 4.2).

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

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 & Discussion

According to HONIKEL (2003), very fast chilling of muscle is conveniently defined as such that a temperature of 0ºC is reached within 5 hours PM. Figure 1 shows that HBVFC regime caused a rapid temperature fall. After two hours the surface temperature was near to -1°C and the inner temperature was close to 0ºC.

HB0 muscles (LD) took 10h PM to reach 5ºC at the center of the muscle and the AT muscles, needed 24h to reach 5°C (data not shown).

The pH values in Table 1 show that at 24 h PM there was a significant difference between HBO and TA treatments ($p<0,05$). Muscles cooled in the carcass (TA) had lower pH values than hot boned muscles cooled at 0°C (HBO).

No significant difference between treatments was observed until 8 hours PM ($p>0,05$) and in the 7th and 14th day PM.

The rate of pH fall was not affected by the HBVFC treatment.

In the first 6 hours, the HBO muscles had high R values at 1h and 6h PM ($p<0,05$) (Table 1). As suggested by HONIKEL (1981) R values > 1,1 and the pH values <5,9,

means that the muscle is in rigor mortis. According to this statement, the results from Table 1 indicate that at six hour PM the HBO and HBVFC muscles were in rigor mortis.

There was a great variability in R values for the HBVFC treatment; it increased very fast from the 4th to 6th hour PM and decreased from 6th to 8th hour PM.

At 24h PM HBVFC muscles had mean R value lower than HBO ones ($p<0,05$) and this indicates that from 6 to 24 h PM the rate of conversion of ATP decreased for the HBVFC muscles.

AT treated muscles presented the lowest mean R value at 6 hour PM indicating that their rigor mortis was delayed.

Sarcomere length was measured at boning and after 14 days PM. As can be seen in Table 2 at boning there was no statistical difference in the sarcomere length for all treatments. At the 14^{th} day PM, HBVFC samples had their mean sarcomere drastically reduced to 1,23µm and significantly lower than those of other treatments ($p<0,05$). This length of sarcomere clearly indicates that cold shortening occurred.

The HBO muscles had their sarcomeres slightly reduced after 14 days of aging, showing an average length of 1,90µm and there was no significant difference in the sarcomere length of HBO and AT muscles.

Even though the time-temperature and pH values of HBO muscles after 10h PM could induce cold shortening according to THOMPSON (2002), the average sarcomere length at the 14^{th} day can be seen as an average sarcomere length for a muscle not shortened after rigor resolution has occurred.

No difference was found in shear force values amongst any of the treatments at 2^{nd} day PM (Table 3). However, at 7^{th} and 14^{th} day PM the HBVFC muscles were significantly tougher than the conventionally chilled (AT) ($p<0,05$) but there was no difference to HBO muscles ($p>0,05$).

The reduction of shear force with aging was observed in treatments HBO and AT. In the HBO and AT samples the shear force values decreased significantly after 7 days, but not from the 7^{th} to 14^{th} day PM. In the case of HBVFC samples, there were no significant differences in shear forces during all the aging period ($p<0,05$).

After 14 days HBVFC samples, which had the shortest sarcomere length, had also the highest shear force values. Tenderness scores (Table 3) clearly indicated higher meat toughness for HBVFC muscles after 14 days PM ($p<0,05$).

Tenderness scores for HBO samples do not show statistical difference in relation to AT samples after 14 days of aging ($p>0,05$).

Tenderness scores shows that from the 2^{nd} to 7^{th} day PM HBVFC samples tenderized with aging. In the case of HBO and AT samples, tenderization occurred from the 2^{nd} to 14^{th} day ($p<0,05$).

The panelists did not perceive differences in juiciness neither between treatments nor for each treatment during aging (Table3).

“Aged flavor” scores in Table 3 show no significant differences between treatments in 2, 7 and 14 days PM ($p>0,05$) but analyzing each treatment separately, “aged flavor” scores were significant different from the 2^{nd} to 7^{th} and from 7^{th} to 14^{th} day PM.

Drip losses of HBVFC muscles were significantly higher ($p<0,05$) than other treatments at 2, 7 and 14 days PM (Table 4). At 2^{nd} day PM, HBVFC muscles showed 1,6 times more mean dripping losses than the HBO muscles and 3 times more than AT muscles. At 14th day PM HBVFC muscles had 2,95 times more dripping losses than

HBO muscles and 2,25 times more than AT muscles. This result agrees with VAN MOESEKE (2001) and HONIKEL (2003).

There was an increase in drip losses during the aging period for all treatments ($p<0,05$). HBO and HBVFC muscles showed significant differences in the average drip losses from the 2nd to the 14th day PM. AT muscles were significantly different from the 2nd to 7th day but not from 7th to 14th day PM.

As can be seen in Table 4, there were no differences in cooking losses between treatments at 2, 7 and 14 days PM and for each treatment with aging time ($p<0,05$).

Conclusions

The results suggest that application of very fast chilling to Nelore steer meat is not practical commercially. HBVFC toughens vacuum packed hot boned beef, increases drip losses and aging is not effective.

The HBO treatment showed no difference to HBVFC considering muscle shear force while sensory analysis showed no significant differences in tenderness scores between HBO and AT cuts, being both more tender than HBVFC muscles.

Considering the effect of aging, the treatments AT and HBO showed the smaller shear force values after 7 days PM, but this improvement in tenderness was noticed by the sensory panel only after 14 days PM, what means that full tenderization will happen only after two weeks.

In spite of differences in drip losses, differences in juiciness were not perceived by trained panelists.

Aging improved “aged meat flavor” for all treatments.

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Tables and Figures

Table 1. Mean pH and R values and standard errors (SE) for muscle *L. dorsi* from different
treatments at 1, 2, 4, 6, 8, 24h and at 7 and 14 days PM

Measurement	Treatment					
	HBO		HBVF		AT	
	Mean	SE	Mean	SE	Mean	SE
pH						
1h PM	6,27	±0,10	6,15	±0,10	6,37	±0,07
2h PM	6,16	±0,13	6,16	±0,10	6,21	±0,07
4h PM	5,99	±0,10	6,10	±0,07	6,17	±0,09
6h PM	5,96	±0,08	5,90	±0,05	5,94	±0,10
8h PM	5,92	±0,09	5,72	±0,06	5,82	±0,12
24h PM	5,71^{a,x}	±0,04	5,60^{ab}	±0,05	5,53^{b}	±0,07
7 days PM	5,52^{y}	±0,02	5,46	±0,04	5,48	±0,03
14days PM	5,52^{y}	±0,03	5,45	±0,08	5,45	±0,05
R value						
1h PM	1,01^{a}	±0,02	0,88^{b}	±0,01	0,92^{b}	±0,03
2h PM	1,05	±0,05	0,93	±0,02	0,93	±0,04
4h PM	1,10	±0,05	0,94	±0,11	0,97	±0,02
6h PM	1,25^{a}	±0,06	1,26^{a}	±0,03	1,07^{b}	±0,04
8h PM	1,30	±0,05	1,15	±0,12	1,11	±0,06
24h PM	1,41^{a}	±0,01	1,22^{b}	±0,06	1,32^{ab}	±0,05
7 days PM	1,45	±0,01	1,41	±0,15	1,37	±0,06
14days PM	1,41	±0,02	1,37	±0,11	1,32	±0,08

Table 2. Mean sarcomere length (SL) and standard error (SE) for muscle *L. dorsi* from different treatments at 0, 2 and 14 days PM

Measurement	Treatment					
	HBO		HBVFC		AT	
	Mean	SE	Mean	SE	Mean	SE
SL	µm		µm		µm	
0 days PM	2,04^{x}	±0,05	1,71	±0,20	-	-
2 days PM	-	-	-	-	2,09	±0,09
14days PM	1,90^{a,y}	±0,02	1,23^{b}	±0,04	1,98^{a}	±0,06

a, b, Treatment effect. Means in the same line with unlike superscripts are different $p< 0,05$

x, y, z Aging effect. Means in the same column with unlike superscripts are different $p< 0,05$

Table 3. Mean shear force and sensory analysis scores for tenderness, juiciness and flavor and standard error (SE) for muscle *L. dorsi* from different treatments at 2, 7 and 14 days PM.

Measurement	Treatment					
	HBO		HBVFC		AT	
	Mean	SE	Mean	SE	Mean	SE
Shear Force	kgf		kgf		kgf	
2 days PM	7,39^{x}	±0,50	7,10	±0,42	6,93^{x}	±0,47
7 days PM	5,90^{ab,y}	±0.34	6,77^{a}	±0,47	5,36^{b,y}	±0,36
14days PM	5,14 ^{ab,y}	±0,32	6,13^{a}	±0,32	4,86 ^{b,y}	±0,52
Tenderness						
2 days PM	5,10^{y}	±0,49	4,66^{y}	±0,15	5,44^{y}	±0,27
7 days PM	5,66^{y}	±0,40	5,56^{x}	±0,32	6,07^{xy}	±0,32
14days PM	6,96^{a,x}	±0,32	5,56^{b,x}	±0,25	6,73^{a,x}	±0,39
Juiciness						
2 days PM	6,55	±0,09	6,37	±0,18	6,16	±0,25
7 days PM	6,41	±0,17	6,40	±0,14	6,30	±0,19
14days PM	6,44	±0,13	6,26	±0,16	6,54	±0,21
Flavor						
2 days PM	2,64^{z}	±0,23	2,41^{z}	±0,13	2,91^{z}	±0,22
7 days PM	3,77^{y}	±0,17	3,75^{y}	±0,15	4,01^{y}	±0,14
14days PM	5,05^{x}	±0,18	4,76^{x}	±0,17	4,96^{x}	±0,28

Table 4. Mean drip loss and cooking loss and standard error (SE) for muscle *L. dorsi* from
different treatments at 2, 7 and 14 days PM

Measurement	Treatment					
	HBO		HBVFC		AT	
	Mean	SE	Mean	SE	Mean	SE
Drip loss	%		%		%	
2 days PM	$0,67^{b,y}$	±0,11	$1,59^{a,y}$	±0,29	$0,53^{b,y}$	±0,15
7 days PM	$0,97^{b,xy}$	±0,12	$3,45^{a,xy}$	±0,87	$1,46^{b,x}$	±0,28
14days PM	$1,35^{b,x}$	±0,25	$3,99^{a,x}$	±0,84	$1,77^{b,x}$	±0,36
Cooking loss						
2 days PM	26,19	±0,52	28,83	±1,34	30,54	±2,39
7 days PM	26,03	±1,77	29,95	±1,44	28,58	±0,94
14days PM	29,70	±1,53	28,51	±1,29	27,64	±1,12

a, b, Treatment effect. Means in the same line with unlike superscripts are different p< 0,05

x, y, z Aging effect. Means in the same column with unlike superscripts are different p< 0,05

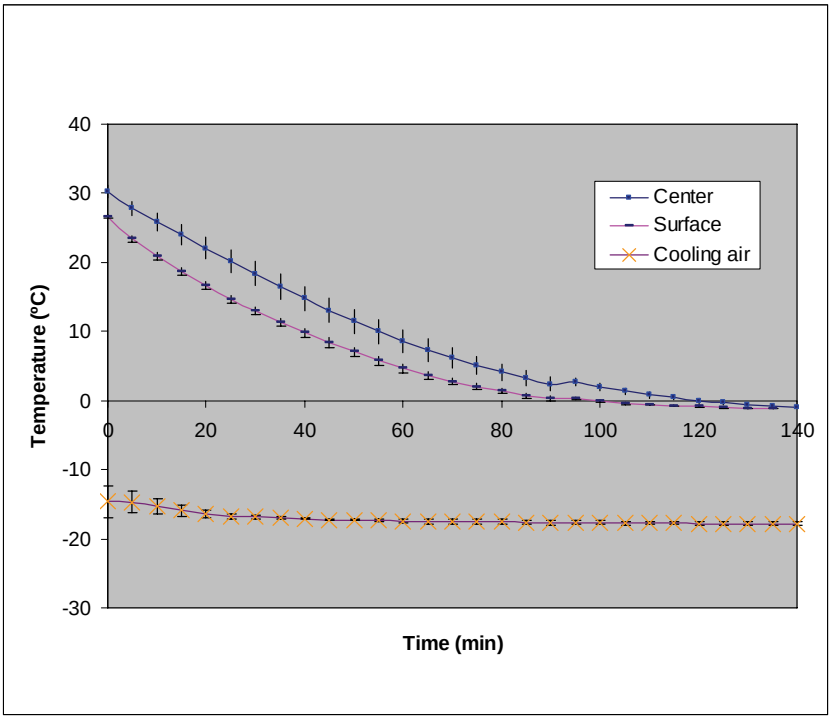

Figure 1. Chilling times in the surface and center of hot boned Longissimus dorsi vacuum packed cut chilled in a tunnel freezer at – 20ºC.