PHYSICAL AND CHEMICAL CHARACTERISTICS OF OUTSIDE ROUND AS AFFECTED BY BONING METHODS, CALCIUM CHLORIDE AND POLYPHOSPHATES INJECTION

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Background

Many research efforts are focused on the improvement of beef tenderness. It is essential to improve and develop different *post mortem* processes to increase meat tenderness, particularly in those muscles that are traditionally tough. Enhancement solutions, containing salt and phosphates have been studied extensively in pork to provide consumers with enhanced, more tender, juicy products (BREWER et al., 2002), but to a less extent in beef (BOLES & SHAND, 2001). One area of research that has shown great promise is the activation of calpain enzyme system with the injection of exogenous calcium chloride, which has been shown to improve tenderness in beef from the loin to the bottom round (GONZALES et al., 2001; PAZOS et al., 2002). However, some of the sensory properties, such as color and flavor, can be altered by this treatment on tough muscles. Hot boning presents economical advantages since it reduces chilling losses and costs of refrigeration, labor and transportation (PISULA & TIBURCY, 1996). *Post mortem* time, temperature and rate of glycolisis can affect the attributes of meat products made from whole tissue muscles , especially products made from hot boned meat (BOLES & SWAN, 1997).

Objectives

The purpose of this study was to evaluate the effect of the boning practices (HB and CB), calcium chloride (IC) and polyphosphates (IP) injection on the cooking yield, pH, objective tenderness (Warner Blatzler shear – WBS) and color of *Biceps femoris* muscle.

Methodology

Grass fed Nelore (*Bos indicus*) steers (n=36, average weight=435kg, average age=30-36months) were captive bolt stunned and carcasses were low voltage electrically stimulated (20V(rms) / 60Hz/0.25 amps/ 90s) immediately after bleeding. Carcasses were halved, one side was hot boned approximately 45 min after slaughter and the *Biceps femoris* muscles removed. Hot boned muscles (HB) were conditioned for 15 hours at 25ºC then at 7ºC until the temperature reached 15ºC, followed by 0ºC until the center of the muscle reached 5ºC. The conventionally chilled carcasses were held at 2ºC during 24hours prior to removing the *Biceps femoris* muscles (CB). The CB and HB muscles were injected with two different brines, one containing 2.4% sodium chloride in calcium chloride 150mM (CI) and the other containing 2.4% sodium chloride and 1.8% polyphosphates blend (KENA 27- Rhodia Food) (PI). The beef cuts were randomly assigned to five treatments: Non injected cold boned (CB/NI); Non injected hot boned (HB/NI), CB/CI, CB/PI, HB/CI. Pumped muscles were injected to approximately 15% of the green weight using a twelve needles injector (Lingaard mod 500, 42l/min). Injected and non injected muscles were divided into two roasts, which were vacuum packaged in shrinkable (CRYOVAC) bags and allowed to tempering at 0ºC during 20 hours, followed by cryogenic freezing in liquid nitrogen and stored at –20ºC during six months prior to the analysis. Brining retention (BR) after injection was determined. Samples were analyzed for moisture, fat, protein, ash and chloride contents according to AOAC (1995). Three pH measurements were taken in the raw meat, after boning (BI), after injection (AI) and after thawing (AT). The cuts were weighed after thawing during 24 hours at 4ºC to determined thawing loss (TL) after six months storage at –18ºC. Cooking losses (CL) were determined after broiling the steaks on a preheated electric broiler (SIRMAN) until an internal temperature of 72ºC was reached. Warner Blatzler shear force (WBS) of 1.27X1.27x2.54 cm core samples sheared perpendicular to the fiber direction in two steaks for each muscle were determined with a TAXT2i Texture analyzer (full scale load 5kg/crosshead speed 200 mm/min) attached to a Warner Blatzler accessory, following the same procedure used for CL. Instrumental color determinations were made on the surface of non injected and injected raw samples, BI, AI and AT, under D_{65} illuminant and a 10^{o} angle, using a Minolta spectrophotometer (model CM508-9) and CIE LAB values (L*, a* and b*) were calculated. Data were analyzed as a 2 X 3 factorial treatment design with boning method (HB, CB) and brine injection (NI,CI,PI) as main factors. All treatments were applied to a single cut so that cut was considered a replicate (6 cuts were used for each treatment). Tukey's test ($p<0.05$) was used to identify the effects significance and the differences among means.

Results and discussion

Brine injection had a significant effect on moisture, ash, protein and collagen contents ($p<0.01$). It was observed a strongly increase in ash (~100%) and a slightly increase in moisture (~1%) amounts for injected samples, despite of the brine composition (**Table 1**). Collagen and protein had their amounts slightly decreased after injection, as expected. No effects of boning practice or interactions were detected for proximate composition. Boning practice showed no effect on muscle pH BI ($p>0.05$), suggesting that the electrical stimulation was effective in lowering the pH of hot boned muscles after conditioning (**Table 2**). Boning practice and brine injection as well as the interaction between these factors showed significant effect on muscles pH measurements after injection, although both brine injection and the interaction between brine injection and boning practice had significant effect on pH measurements after thawing the muscles (**Table 2**). The boning practice had no effect on brine retention ($p>0.05$), although the brine injection ($p <0.01$), as well as the interaction between boning X injection ($p<0.01$), showed significant effects on BR. CB muscles injected with the CI brine showed significantly ($p<0.05$) lower BR (**Table 3**) than the other treatments. Brine injection showed significant effect on TL ($p<0.01$) and CL ($p<0.01$). The boning practice showed significant effect only on CL ($p<0.01$), which showed lower values for HB muscles. Only brine injection affected WBS ($p<0.05$) and the PI brine treatments showed lower WBS values than the others. The boning practice did not affect the measured objective color parameters ($p>0.05$) before injection (**Table 4**). After injection the L* and b* values were significantly affected by the brine injection($p<0.01$ and $p<0.05$, respectively). The L* values for PI injected muscles were lower than the other treatments, while the lowest b* values corresponded to CI injected. After thawing, L* values were significantly affected by brine injection ($p<0.01$), while a* values were affected by the boning practice, where HB muscles had the lower values.

Table 1. Moisture, protein, lipids, ash and collagen contents in hot and cold boned *Biceps femoris* muscles injected with different brines.

Boning	Brines	Moisture	Protein	Lipids	Ash	Collagen
HB	NI	76.18 [b,c]	20.77 [a]	2.26 [a]	1.10 [b]	1.53 [a]
	CI	76.93 [a]	19.73 [a]	2.17 [a]	2.21 [a]	1.08 [a]
	PI	77.02 [a]	17.75 [a]	2.46 [a]	2.37 [a]	1.08 [a]
CB	NI	75.63 [b,c]	19.39 [a]	2.22 [a]	1.13 [b]	1.34 [a]
	CI	76.84 [a,c]	18.74 [a]	2.07 [a]	2.38 [a]	1.04 [a]
	PI	77.49 [a]	17.61 [a]	2.08 [a]	2.44 [a]	0.92 [a]

(*) Means within a column with different letters are not significantly different (p>0.05)
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NI – non injected

Table 2. Brine retention after injection (BR) and pH measurements after injection before injection (BI), after injection (AI) and after thawing (AT) of hot and cold boned *Biceps femoris* muscles, injected with different brines.

Boning	Brines(*)	pH		
		BI	AI	AT
HB	**NI**	5.41[a]	5.59[a]	5.45[a]
	CI	5.51[a]	5.60[a]	5.45[a]
	PI	5.48[a]	5.64[a]	5.51[a]
CB	NI	5.53[a]	5.70[a]	5.46[a]
	CI	5.55[a]	5.52[a]	5.32[b]
	PI	5.51[a]	5.68[a]	5.57[a]

Means within a column with different letters are not significantly different (p>0.05)
NI – non injected

Table 3. Brine retention (BR), thawing losses (TL), cooking losses (CL) and Warner Blatzler shear force (WBS) measurements in hot and cold boned *Biceps femoris* muscles injected with different brines.

Boning	Brines*	BR (%)	TL (%)	CL (%)	WBS (kgf/cm^2)
HB	**NI**	0	12.5[a]	32.1 [b]	4.99 [a]
	CI	13.0[a]	6.1 [a,b]	36.7 [a,c]	4.59 [a]
	PI	13.4[a]	5.3 [b]	34.3 [b,c]	4.35 [b]
CB	**NI**	0	8.0 [a,b]	35.7 [a,b,c]	5.92 [a]
	CI	11.3[b]	7.1 [a,b]	39.6 [a]	5.24 [a]
	PI	13.1[a]	4.1 [b]	36.1 [a,b,c]	4.36 [b]

Means within a column with different letters are not significantly different (p>0.05)
NI – non injected

Table 4. Objective color measurements (L*, a*, b*) before injection, after injection and after thawing of hot and cold boned *Biceps femoris* muscles injected with different brines.

Boning	Brines*	Before injection			After injection			After thawing		
		L*	a*	b*	L*	a*	b*	L*	a*	b*
HB	NI	33.70 [a]	18.56 [a]	6.68 [a]	34.84 [a]	16.66 [a]	6.60 [a,b]	32.29 [a]	14.63 [a]	6.43 [a]
	CI	33.42 [a]	18.24 [a]	6.84[a]	32.44 [a]	16.78 [a]	5.84 [a,b]	27.99 [a,b]	12.71 [a]	1.41 [a]
	PI	34.16 [a]	18.23 [a]	6.64 [a]	30.77 [a]	16.02 [a]	4.17 [b]	25.86 [a,b]	13.29 [a]	6.13 [a]
CB	**NI**	33.83 [a]	17.67 [a]	5.82 [a]	35.98 [a]	17.47 [a]	8.62 [a]	31.00 [a,b]	16.07 [a]	5.98 [a]
	CI	33.91 [a]	17.96 [a]	6.19 [a]	32.01 [a]	15.41 [a]	4.03 [b]	26.63 [a,b]	13.71 [a]	7.42 [a]
	PI	34.31 [a]	17.86 [a]	6.46 [a]	31.10 [a]	15.18 [a]	4.64 [a,b]	24.16 [b]	16.22 [a]	6.97 [a]

Means within a column with different letters are not significantly different (p>0.05)
NI – non injected

Conclusions

The low voltage electrical stimulated and hot boned outside round, injected with either polyphosphates or calcium chloride containing brines at approximately 10% over green weight showed an improve over non injected treatments on the physical and chemical attributes evaluated. A lot of variation was observed between muscles for brine retention after injection, probably due to the type of equipment used, which could be controlled by changing brine pressure of the needle injector to increase dispersion. Further work will evaluate the influences of HB and CB, along with the brine composition, on eating quality of outside round roasts.

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