Effects of Electrical Stimulation on Fat-Emulsifying Capacity, Water-Holding Capacity, pH and Thawing Weight Loss of Beef Muscles.

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SUMMARY

A study was made of the effects of electrical stimulation on fat-emulsifying capacity (FEC), water-holding capacity (WHC), pH, and thawing weight loss (TWL) in muscles from carcasses of Nelore (*Bos indicus*) and Pitangueiras, 5/8 Red Poll (*Bos Taurus*) x 3/8 Zebu (*Bos Indicus*), breeds.

In general, breed did not affect the parameters. Electrical stimulation increased the rate of glycolysis, decreased significantly the FEC, and practically did not affect the WHC and TWL. Pre- and post-rigor state of the muscle did not influence FEC, but WHC was superior for pre-rigor muscle. Frozen storage and thawing decreased FEC and WHC, and increased TWL.

The results suggest that the use of electrically stimulated beef in emulsified meat products, especially for high fat content products, should be further studied.

INTRODUCTION

Meat researchers have suggested several hypotheses to explain the increasing tenderizing effect caused by electrical stimulation (ES) of carcasses: cold-shortening prevention (CHRYSTALL and HAGYARD, 1975; BENDALL et al., 1976); fiber rupture (SAVELL et al., 1978); WILL et al., 1980; TAKAHASHI et al., 1983); increased proteolytic-enzyme activity (DUTSON et al., 1980); modification in collagen structure (JUDGE et al., 1980); and precipitation of sarcoplasmic proteins (GEORGE et al., 1980). All of these hypotheses consider that ES causes modifications in the muscle fiber structure. NORMAN (1982) observed significant differences in muscle fiber

(diameter and bundle size) and thermal stability of collagen of beef muscles from different breeds: Nelore and Guzerá (*Bos Indicus*), Charolais (*Bos Taurus*), and Canchim (5/8 Nelore x 3/8 Charolais).

During ES all muscles are submitted, with different intensities to a massive contraction which could affect muscle properties in meat processing. Electric stimulation may exert different effects on muscles from distinct animal species.

This work was conducted to evaluate the effects of ES on fat-emulsifying capacity, water-holding capacity, pH and thawing weight loss in muscles from carcasses of Nelore and Pitangueiras breeds.

MATERIALS AND METHODS

Twenty-four steer carcasses: 12 Nelore (NEL), Zebu breed (*Bos Indicus*), and 12 Pitangueiras (PIT) crossbred 5/8 Red Poll (*Bos Taurus*) x 3/8 Zebu, with average weight of 224,7 kg, were dressed and split. Within 25 minutes postmortem, one side of each carcass was electrically stimulated (ES) (700V; 8.5 pulses/second) during 2 minutes; the paired side was not stimulated (NS). *Sternomandibularis* muscles were excised from both sides 30 minutes postmortem, divided into two pieces and put in polyethylene bags. In the first piece from each side at 50 min. postmortem (kept at room temperature) and in the second piece at 48 hours postmortem (kept at 15ºC for 10 hours and then at 0ºC until 48 hours), the following parameters were determined: pH (BENDALL, 1973); fat-emulsifying capacity (FEC) in duplicate (SWIFT et al., 1961; results are presented in milliliters of peanut oil per 2.5g of muscle to break the emulsion): and water-holding capacity (WHC) in triplicate (WIERBICKI and DEATHERAGE, 1958), using two minutes for pressing. (Results are expressed in square centimeters per 500 milligrams of muscle). *Triceps brachii* muscles were excised 72 hours postmortem from chilled NS and ES sides, divided into 4 pieces, and put into polyethylene bags. Three pieces were frozen and stored at -20ºC. The frozen pieces were thawed for 48 hours at 5ºC before measurements were made. In pieces from paired sides at 72 hours postmortem (chilled) 6, 90 and 180 days (frozen/thawed), pH, FEC, WHC, and thawing weight loss (TWL) were determined. After thawing, excess superficial juice was removed with a paper towel. The TWL results are expressed as the loss during

storage and thawing per 100g of initial (prefreezing)sample. Data were statistically analysed using the completely randomized split-split-plot design, F test for means and Tukey test for multiple mean comparison at significance level of 5%.

RESULTS AND DISCUSSION

1. Pre- and post-rigor *Sternomandibularis* muscle

Breed did not influence parameters values except for WHC in the pre-rigor state. In this case, muscle from the ES side of NEL had a smaller WHC (higher WHC values indicate smaller water-holding capacity) than ES sides from PIT. The electrical stimulation promoted a decrease of 0.2/unit in pre-rigor pH, a decrease of FEC for pre- and post-rigor muscle of about 9.5%; it did not influence WHC of pre- and post-rigor muscle. As the muscle went from the pre- to the post-rigor state, FEC did not change and WHC decreased. (TABLE 1).

WHITING et al. (1981) found higher values of FEC in ES post-rigor lamb muscle for slow chilled, and lower values of FEC for fast chilled, than in NS muscles. In the same work, ES did not affect the level of sarcoplasmic proteins and salt-soluble proteins independent of chilling rate. The authors concluded that ES did not cause an irreversible reaction in the ability of myofibrillar proteins to emulsify fat. TERRELL et al.(1982) found that ES did not affect the salt-soluble proteins in pre- and post-rigor *Semimembranosus* muscle. Electrical stimulation of beef carcasses causes a denaturation of sarcoplasmic proteins which precipitate on the fibrillar proteins(GEORGE et al., 1980); this phenomenon could explain the smaller FEC of stimulated muscles.

WHITING et al. (1981) found inconsistencies and minimal effects of ES on the WHC of post-rigor lamb muscle. TERRELL et al. (1981) did not find a significant difference ($p > 0.05$) in the WHC of ES and NS beef muscles. WHC results of this work agree with th results of MILLER et al. (1980), who found increasing WHC as pH increased.

2. Post-rigor, frozen thawed *Triceps brachii* muscle.

a) pH.

Breed and electrical stimulation did not affect pH during storage (TABLE 2). Changes ($p < .05$) in pH values observed during frozen storage probably reflect small variation in buffer standardization of the meter rather

TABLE 1. Results(1) of pH, fat-emulsifying capacity (as ml of oil/2.5g of muscle) and water-holding capacity (as cm^2/500mg of muscle); *Sternomandibularis* muscle.

BREED & TREATMENT	pH		FEC		WHC VALUE	
	pre-rigor	post-rigor	pre-rigor	post-rigor	pre-rigor	post-rigor
NEL NS	** 6.93(0.03)^{a}	5.55(0.03)^{b}	** 53.5(0.5)^{a}	** 53.3(0.4)^{a}	19.9(0.8)^{a}	24.9(0.8)^{b}
NEL ES	6.73(0.05)^{a}	5.51(0.02)^{b}	48.2(0.7)^{a}	48.9(0.4)^{a}	21.6(0.8)^{a}	25.7(1.0)^{b}
PIT NS	6.98(0.02)^{a}	5.56(0.03)^{b}	53.3(0.6)^{a}	52.8(0.6)^{a}	* 20.6(1.2)^{a}	24.8(1.0)^{b}
PIT ES	** 6.80(0.04)^{a}	5.52(0.02)^{b}	** 48.5(0.4)^{a}	** 48.1(0.5)^{a}	19.1(1.0)^{a}	27.1(0.5)^{b}

(1) mean, mean standard error (in parentheses)

a,b... means within a row, for the same parameter, bearing a different superscript letter are different ($p < 0.01$)

means within a columm liked by a vertical bar are different if followed by * ...($p < 0.05$) or ** ... ($p < 0.01$)

than real differences due to main effects or storage temperature.

b) FEC

Breed did not affect FEC during storage. On the other hand, electrical stimulation decreased significantly the FEC of muscles from NEL and PIT breeds; in addition, FEC values decreased as storage time increased (TABLE 2). The difference caused by ES may be due to the precipitation of sarcoplasmic proteins in layer form over the

TABLE 2. Results[1] of pH and fat-emulsifying capacity (as ml of oil per 2.5g); *Triceps brachii* muscle.

PARAMETER	BREED & TREATMENT		POST-RIGOR	6 DAYS	90 DAYS	180 DAYS	LSD 5%
pH	NEL	NS	5.45(.04)^{b}	5.46(.01)^{b}	5.59(.02)^{a}	5.55(.02)^{a}	.06
	NEL	ES	5.43(.02)^{b}	5.42(.01)^{b}	5.58(.01)^{a}	5.53(.02)^{a}	.06
	PIT	NS	5.40(.01)^{c}	5.44(.02)^{c}	5.61(.02)^{a}	5.54(.01)^{b}	.06
	PIT	ES	5.39(.01)^{c}	5.43(.02)^{c}	5.60(.02)^{a}	5.51(.01)^{b}	.06
FEC	NEL	NS	53.3(.4)^{a} **	53.8(.4)^{a} **	50.3(.3)^{b} **	49.5(.2)^{b} **	1.3
	NEL	ES	48.1(.4)^{a,b}	48.4(.5)^{a}	47.8(.3)^{b}	46.9(.3)^{b}	1.3
	PIT	NS	53.0(.4)^{a}	53.8(.4)^{a}	50.0(.2)^{b}	49.3(.2)^{b}	1.3
	PIT	ES	48.2(.4)^{a,b} **	49.1(.4)^{a} **	47.2(.3)^{b,c} **	46.4(.2)^{c} **	1.3

(1) mean, mean standard error (in parentheses)

a,b,c,... means within a row bearing a common superscript letter are not different ($p > 0.05$)

means within a columm liked by a vertical bar are different if followed by: ** ($p < 0.01$)

LSD... Least Significant Difference.

TABLE 3. Results[1] of water-holding capacity (as cm^2/500mg) and thawing weight loss (as percent of initial sample weight); *Triceps brachii* muscle.

PARAMETER	BREED & TREATMENT	POST-RIGOR	6 DAYS	90 DAYS	180 DAYS	LSD 5%
WHC value	NEL NS	25.6(.7) a,b	24.4(1.0) b,c	22.1(.8) c	28.0(1.4) a	3.2
	NEL ES	25.2(.7) a,b	26.1(1.1) a,b	23.9(.8) c	27.5 (.6) a	3.2
	PIT NS	24.4(.8) a,b,c	26.3 (.8) a,b	22.7(.8) c	27.5(.4) a	3.2
	PIT ES	25.3(.8) b	26.2(1.3) b	24.6(.7) b	30.3(.7) a *	3.2
TWL	NEL NS	-	6.56(.52) b	9.32(.41) a	9.46(.51) a	1.28
	NEL ES	-	7.00(.39) b	9.68(.28) a *	9.72(.47) a	1.28
	PIT NS	-	6.55(.53) c	7.67(.34) b	9.09(.58) a	1.28
	PIT ES	-	7.04(.42) b	9.28(.40) a **	8.86(.37) a	1.28

(1) mean, mean standard error (in parentheses)

a,b,c... means within a row bearing a common superscript letter are not different ($p > 0.05$)

means within a columm liked by a vertical bar are different if followed by: *($p < 0.05$) or ** ($p < 0.01$).

LSD... Least Significante Difference.

myofibrillar proteins as described by GEORGE et al. (1980), even though TERRELL et al. (1982) found no difference in the level of salt-soluble proteins from ES and NS beef muscles stored for 8 months.

c) WHC and TWL

Breed did not affect WHC values. ES decreased WHC only for 180 days interval for PIT breed. From 6 to 90 days, WHC appered to rise (decline in "WHC value"); but it fell appreciably during the 90 - 180 days interval (TABLE 3). MILLER et al. (1980) observed a steady decline of WHC during frozen storage of muscle up to 180 days.

At 90 days of storage ES increased TWL for PIT breed; and NS muscles from NEL presented higher TWL than NS muscles from PIT. Breed and ES did not affect TWL values for others storage periods. TWL increased as time of storage increased (TABLE 3), which agrees with the results presented by MILLER et al. (1980).

The reduction of WHC and the increase of TWL throughout the storage periods are primarely caused by insolubilization of sarcoplasmic proteins and actmyosin (AWAD et al., 1966), and the results of this work suggest that this situation was not affected by breed or ES.

CONCLUSION

TERRELL et al. (1981) found that ES affected some muscle properties when determined in the laboratory, but concluded that the use of ES muscle in emulsified meat products would not bring any advantage or disadvantage in meat processing. On the other hand, the results of this work show that ES decreases FEC significantly, and suggest that the incorporation of ES beef in emulsified meat products, especially those of high fat content should be studied further.

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