QUALITY ASSESSMENT OF BOVINE MUSCLE INJECTED WITH SODIUM PYRUVATE

A.A. Al-Sahal Al-Shathri*[1], M.E. Dikeman[2], and C.L. Kastner[2]

1Department of Food Science & Nutrition, College of Agricultural & Food Sciences, King Faisal University, Al-Ahsa, P.O.Box 420, PC 31982, Saudi Arabia
2Department of Animal Sciences and Industries, Kansas State University, Manhattan, KS 66506, USA

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Introduction

Less tender meat is perceived as undesirable for consumers due to the difficulty that they experience during eating. Tenderness variability in pork and lamb is of minor concern compared to beef due to the age of slaughter for beef and the maturity of its collagen (Dikeman, 1996). Glycolysis and its products are the cause of the majority of quality changes that take place postmortem. The relationship between pH and glycogen content of muscles could be clarified by studying glycolysis and its products. Three major products of glycolysis are produced in a total of nine reactions: chemical energy in the form of ATP, chemical energy in the form of NADH, and pyruvate (Caret et al., 1993). The reduction of pyruvate into lactate by the enzyme lactate dehydrogenase has been responsible for the accumulation of lactate and, consequently, the ultimate pH in muscles.

Tran (1975) indicated that the addition of sodium pyruvate to fish fillets greatly improved their hydration capacity upon frozen storage. Also, sodium pyruvate showed a tenderizing effect on cod fish fillets when flooded with 10% solution in a shallow pan and stored for different periods of time (8, 22, 54, and 180 d of storage at -23°C) (Tran, 1975). Even though lactate as an end product of glycolysis and its effect on the quality and safety of meat have been the subject of many researchers (Whiting and Strange, 1990; Duxbury, 1990; Papadopoulos et al., 1991b; Papadopoulos et al., 1991a), pyruvate has received less attention. Therefore, the main objective of this study was to investigate the possible effect of sodium pyruvate on some of the quality traits of beef semitendinosus muscle.

Materials and Methods

Whole beef semitendinosus muscles (US Choice, n=27) were obtained at 48 h postmortem from a commercial processing plant. All muscles were trimmed from external fat and assigned to one of the three treatments: control (C) (injected with the needle only), injected with water (W) 10 % of the weight, and injected with 10% sodium pyruvate in water solution (SPW). Three replications were employed in three different days. Injection was conducted using a plastic 50 cc syringe with a single needle (1.6x38 mm). After treatments, muscles from each treatment were sealed in a plastic bag, tumbled in a drum tumbler for 30 min, and then sliced into six 2.54 cm in thick steaks. Two steaks of each muscle/treatment (total of six steaks per treatment) were used. Color was measured with LabScan 2000 Spectrocolorimeter as an average from three different locations on each steak. The remaining four steaks from each muscle/treatment were vacuumed packaged and aged in a cooler at 2°C. Two steaks were aged for 2 d and the other two were aged for 7 d.

One steak from each aging period was ground two times through a fine blade using meat grinder. Moisture and fat were determined by AOAC (2002) method using CEM technology. PH values were measured according to AOAC (2002). WHC was evaluated using Jauregui et al., (1981) method. The second steak from each treatment was cooked to an internal temperature of 70°C in a Blodget oven set at 163°C. After cooling at 2°C to the following day, six 1.27 cm diameter cores were removed parallel to the muscle fibers from each steak and sheared using Instron Model 4201 Universal Testing Machine with a Warner-Bratzler shear attachment. The compression load was set at 50 kg and crosshead speed was 250 mm/min.

The statistical design was a two-way split plot for injection treatments (C, SPW, and W) and aging treatments (2 d and 7 d). Data were analyzed using the GLM procedure of SAS (2000). The statistical model included effect of injection treatments, aging treatments and all possible interactions on proximate (% fat, % protein, and % moisture), pH, %WHC, shear force (kg), %drip loss, %cooking loss, %overall loss, and color. Least-squares means were used to determine significance when a significant F-ratio was obtained in the analysis of variance.

Results and Discussion

The statistical results indicated that there were no interactions ($P > 0.05$) between injection treatments (SPW, W, and C) and aging treatments (2 d and 7 d) for all traits evaluated of this study. Thus, overall main effects were compared.

Proximate Analysis. Injection Treatments: Fat content (Table 1) showed no difference ($P > 0.05$) among C, W, and SPW treated muscles. Moisture percentage was less ($P < 0.05$) for C compared to both SPW and W treatments, with no difference ($P > 0.05$) between SPW and W treatments. These results were expected because the C treatment did not include the addition of water, while W and SPW treated muscles were injected with 10% of their weight with water or water plus sodium pyruvate, respectively. Protein content was estimated by difference.

Aging treatments: Data indicated that there was no difference (*P* >0.05) in fat content of all samples over aging periods of 2 d or 7 d (Table 1). However, moisture content was higher (*P* <0.05) for 7-d aged muscles compared to 2-d aged muscles. This difference may be because all steaks were aged in vacuum packages, which may have caused chemical changes that increased water absorption. Protein content was estimated by difference.

Table 1. Least squares means for proximate analysis, pH, and %WHC of beef semitendinosus muscle by treatments.

Treatments[1]	% Fat	% Protein	% Moisture	pH	%WHC
Injection:					
C	3.36[a]	25.51[a]	71.27[b]	5.54[b]	39.84[b]
SPW	2.53[a]	24.56[b]	72.90[a]	5.74[a]	43.84[a]
W	3.34[a]	24.55[b]	72.08[a]	5.51[b]	40.77[b]
Aging:					
2-Day	3.10[a]	25.24[a]	71.68[b]	5.59[a]	42.18[a]
7-Day	3.05[a]	24.51[b]	72.49[a]	5.60[a]	40.79[a]

[1]=No interaction between injection and aging treatments, main effects considered for each treatment independently.
[ab]Means in the same column with different superscript letters differ (P<0.05)

pH Values: Injection Treatments: The pH results (Table 1) indicated that SPW treated steaks were higher (*P* <0.05) in pH compared to C and W treatments, with no difference (*P* >0.05) between C and W treatments. This result may be attributed to the effect of sodium pyruvate, which has pH around 5.5 to 6.
Aging treatments: The results indicated no pH difference (*P* >0.05) over the aging periods employed (Table 1).

Water Holding Capacity (WHC): Injection Treatments: The WHC of SPW treated steaks was higher (*P* <0.05) than for C and W, with no difference (*P* >0.05) between C and W (Table 1). This increase in water holding capacity may be credited to the significant increase in the pH of SPW treated steaks. As pH increases, the WHC increases because of the distribution of the negative charges within proteins that causes more water to be held between myofilaments after their repulsion.
Aging treatments: The results indicated no WHC difference (*P* >0.05) over the aging periods (Table 1).

% Drip, Cooking and Overall Losses: Injection Treatments: Percentages of drip and overall losses (Table 2) of W-treated steaks were the highest (*P* <0.05). Also, percentages of drip and overall loss of SPW treated steaks were higher (*P* <0.05) than for C steaks. Percentage of cooking loss of W steaks was higher (*P* <0.05) than SPW and C treatments; however, there was no difference (*P* >0.05) between SPW and C treatments.
Aging treatments: The results (Table 2) indicated no difference (*P* >0.05) in cooking and overall loss over aging periods (2 d and 7 d); however, drip loss was higher (*P* <0.05) in 2-d aged steaks compared to 7-d aged steaks (11.3% and 9.66 %, respectively).

Table 2. Least squares means for shear force (kg), %drip loss, %cooking loss, %overall loss, and color (L* a* b*) values of beef semitendinosus muscle by treatments.

					Color		
Treatments[1]	Shear Force (kg)	% Drip Loss	% Cooking Loss	% Overall Loss	L*	a*	b*
Injection:							
C	4.56[a]	7.21[c]	30.71[b]	35.71[c]	38.96[a]	18.65[a]	23.32[a]
SPW	3.78[b]	10.43[b]	31.00[b]	38.19[b]	40.06[a]	15.54[b]	22.96[a]
W	4.77[a]	13.80[a]	35.05[a]	44.00[a]	42.40[b]	16.64[ab]	23.83[a]
Aging:							
2-Day	4.56[a]	11.30[a]	32.18[a]	39.79[a]	N/A	N/A	N/A
7-Day	4.16[b]	9.66[b]	32.33[a]	38.81[a]	N/A	N/A	N/A

[1]=No interaction between injection and aging treatments, main effects considered for each treatment independently.
[ab]Means in the same column with different superscript letters differ (P<0.05)

Warner-Bratzler Shear Force (WBSF)Values: Injection treatments: The results (Table 2) indicated that SPW reduced (*P* <0.05) WBSF values compared to both W and C steaks. The reduction in WBSF values of SPW steaks were 17.1 % and 20.8 % compared to C and W steaks, respectively. However, there was no difference (*P* >0.05) between W and C treatments. This result may be attributed to the hydration effect of sodium pyruvate that was indicated by the increase in WHC of the meat.
Aging Treatments: Table 2 presents the effects of aging periods on WBSF values. As expected, steaks held in for 7-d were more tender (*P* <0.05) than those held for 2-d. These results have been accepted as a fact in meat industry for long time. The reduction was almost 9% in 7-d aged steaks compared to 2-d aged steaks.

Color: Table 2 displays the results of the effect of sodium pyruvate on beef color. No differences ($P > 0.05$) were observed in color yellowness (b* values) over all treatments. Beef treated with water (W) was lighter ($P < 0.05$) in color (L*) than C and SPW. Redness color values (a*) were higher ($P < 0.05$) in C compared to SPW and W treated steaks. This result indicates the deteriorating effect of sodium pyruvate injection on the color of treated steaks.

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