Effect of Sodium Bicarbonate Injection in Pre-rigor Porcine *M. Longissimus lumborum* on Pork Quality

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ABSTRACT : Effects of sodium bicarbonate (SBC) injection on meat quality and functionality of porcine *M. longissimus lumborum* were investigated. Fifteen pigs (100±5 kg) were randomly selected at a commercial slaughter plant. After slaughtering the loins were dissected from the carcass before chilling at approximately 30 minutes *post mortem*. The loins were divided into four cuts for sample treatment, and SBC of 0.25 M, 0.40 M and 0.75 M was injected (2% w/w) using a syringe. As SBC injection level was increased, muscle pH increased significantly ($p<0.05$). SBC injection decreased lightness (L*) values on the surface of muscle. Moreover, with injection of SBC, drip loss %, cooking loss % and shear force were significantly ($p<0.05$) decreased, whereas WHC and Na^+ content were significantly ($p<0.05$) increased. From panel testing of uncooked pork loin, no significant differences ($p>0.05$) were found in aroma, off-flavor and drip between injection of SBC at different levels and the control, although color and acceptability were significantly lower ($p<0.05$) in control pork loin compare with injection of SBC at 0.75 M. In cooked pork loin from the panel test, aroma, flavour, off-flavour and juiciness were found to be similar ($p>0.05$) on all treatments, but tenderness and acceptability were significantly higher ($p<0.05$) with injection of SBC at 0.75 M than for control loin. Myofibrillar protein solubility of muscles treated with SBC was significantly ($p<0.05$) higher than that of the control, although no significant differences ($p>0.05$) were found in sarcoplasmic protein solubility between the treatments. These results indicated that SBC injection into pre-rigor porcine *M. longissimus lumborum* could improve ultimate pork quality characteristics such as meat color, water-holding capacity, and could inhibit muscle protein denaturation due to an increase in muscle pH. ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 6 : 898-904)***

Key Words : Sodium Bicarbonate, *M. longissimus lumborum*, Pork Quality

INTRODUCTION

The occurrence of pale, soft, exudative (PSE) meat is still a major concern in the pork industry. PSE meat is characterized as having a low water-holding capacity (WHC), soft texture and pale color. PSE meat causes problems during the manufacture of cooked products by increasing purge, resulting in dry products with poor texture, and an overall low eating quality. Due to these quality problems, PSE meat is undesirable for both consumers and meat processors.

Generally PSE pork occurs if pigs are genetically prone to porcine stress syndrome (PSS) and are halothane positive (Louis et al., 1993; Ellis et al., 1999). However, PSE pork may result not only from genetic defects, but may develop due to the adverse pH and temperature conditions within the muscle early postmortem. A low pH combined with a high carcass temperature results in denaturation of muscle protein (Bendall and Swatland, 1988; Joo et al., 1999). This protein denaturation is associated with poor characteristics such as a pale color or a low WHC. Since PSE is a temperature and pH related phenomenon it was suggested that reduces carcass temperature could prevent PSE development (Offer, 1984; Andersen et al., 1999; Lee and Choi, 1999). However, it was reported that reducing carcass temperature reduced the magnitude of the problem but did not completely eliminate PSE development (Long and Tarrant, 1990).

Recently, researchers have investigated the use of buffers such as sodium bicarbonate or polyphosphates to increase muscle pH and thus to reduce the occurrence of PSE meat (van Laack et al., 1998). It was reported that infusion of sodium bicarbonate early postmortem reduced the meat quality problems associated with the PSE condition (van Laack et al., 1998; Kauffman et al., 1998). They suggested early postmortem injection of sodium bicarbonate to prevent the development of PSE by increased muscle pH, and decreased drip loss % and muscle lightness (CIE L*). Currently, more than 80% of pork loins in the US are “enhanced” or pumped with a solution containing alkaline phosphate and some salt to increase pH and water-holding capacity (Klont et al., 2002). Wynveen et al. (2001) also reported that early postmortem injection of phosphate and sodium bicarbonate was effective at reducing pH decline and increasing WHC when compared with their respective controls. If, sodium bicarbonate could alter muscle pH, it might be hypothesized that early injection of sodium bicarbonate to pork loin muscle might be a useful method to inhibit PSE development and to improve pork quality characteristics. Therefore, in this study, the effects of sodium bicarbonate injection to pre-rigor porcine *M. longissimus lumborum* on ultimate pork quality characteristics such as color, muscle pH, water holding capacity, shear force and protein solubility at 24 h postmortem were investigated.

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MATERIALS AND METHODS

Sample treatment

A total of fifteen pigs (100±5 kg) were randomly selected at a commercial slaughter plant. At approximately between 30-40 min after slaughter, the *longissimus muscles* of the carcass were dissected and each cut into half (four loin samples were obtained from each pig). Control, Treatment 1, 2 and 3 were injected 0, 0.25 M, 0.40 M and 0.75 M sodium bicarbonate by weigh (2%), respectively. Four injections of 5 ml volume for each time were applied in 4 different places of each sample by a plastic syringe for one treatment. The muscle pH was measured at postmortem 1, 2, 3, 6, 9, 12 and 24 h. CIE L*a*b*, drip loss, cooking loss, water holding capacity (WHC), shear force, sarcomere length, Na^+ content, protein solubility and panel test score were measured at postmortem 24 h.

pH

The muscle pH was measured using a pH-meter (MP230, Mettler, Switzerland) that was calibrated daily with standard pH buffers of 4.0 and 7.0 at 25°C.

Meat color

Surface meat color (CIE L* a* b*) was measured in triplicate on a freshly cut surface after a 30 min bloom time using a Minolta chromameter (Model CR-310, Minolta Co. LTD., Japan). Metric chroma C* and metric hue-angle h were calculated by the formulas: $C^* = (a^{*2}+b^{*2})^{1/2}$ and h = tan-1 (b*/a*) (CIE, 1986).

Water-holding capacity

Meat samples were weighted and transferred to 1 ml open-ended tubes with a 90 μm pore size filter in the bottom of the tube to separate meat from exudate during centrifugation. To prevent surface drying of the meat during centrifugation, the Centrifugal Filter device (plastic tube, Ultrafree-CL, Millipore, USA) were closed with a screw-on cap. The Centrifugal Filter device were put in 1.5 ml eppendorf tubes which were centrifuged at 4°C for various times and speeds. Centrifugation loss of the meat was calculated as the difference in weight before and after centrifugation. Total water content was determined by weighing centrifugation and after heating. WHC was calculated as:

WHC (%) = 1-[(weight of the sample before heating
-weight of the sample after heating and centrifuge)/
total water content of the sample×100]

Drip loss

A standardized muscle cylinder (4 cm diameter×3 cm thick, weighing about 50 g) was suspended in an inflated plastic box (4°C) for 48 h and percentage drip loss was measured as described by Joo et al. (1995).

Drip loss (%) = [(sample weight-48 h after sample weight)/sample weight]×100

Cooking loss

Samples were broiled to an internal temperature of 70°C using a water bath, removed after 20 minutes and surface dried, and weighted. Cooking loss was determined by expressing cooked sample (B) weight as a percentage of precooked samples (A) weight. Cooking loss (%) = [(A-B)/(A)]×100

Sarcomere length

The muscle tissue was cut 3.0×3.0×2.0 cm pieces and placed in a vial and covered with solution A (solution A contained: 0.1 M KCl, 0.39 M Boric acid and 5 mM ethylenediaminetetraaceti acid in 2.5% Glutaradehyde) for 2 h. The sample was transferred to a fresh vial containing solution B (solution B contained: 0.25 M KCl, 0.29 M Boric acid and 5 mM ethylenediaminetetraaceti acid in 2.5% Glutaradehyde) for 17-19 h. On the following day, individual fibers were teased from the muscle bundle and placed on a microscope slide with a drop of solution B. The slide was then placed horizontally in the path of a vertically oriented laser beam to give an array of diffraction bands on the screen. These bands were perpendicular to the long axis of the fibers as described by Cross et al. (1980).

$$\text{Sarcomere length } (\mu m) = [\{632.8\times10^{-3}\times D\times \text{SQRT}((T/D)^2+1)\}/T]\times100$$

Where, D equals distance (mm) from the specimen-holding device to the screen (D = 100 mm) and T equals the separation (mm) between the zero and the first maximum band.

Protein solubility

To determine the solubility of the sarcoplasmic and total (sarcoplasmic+myofibrillar) proteins, two extractions were conducted. Sarcoplasmic proteins were extracted with 10 ml of ice-cold 0.025 M potassium phosphate buffer, pH 7.2 (Helander, 1961) which was added to each of the quadruplicate 1 g muscle samples. The samples were cut up with scissors, homogenized on ice with a Polytron on the lowest setting (3×4 seconds burst to minimize protein denaturation through heating), and then left on a shaker at 4°C overnight. Samples were centrifuged at 1,500×g for 20 min and the supernatants protein concentrations were determined by the biuret method using bovine serum albumin as the standard. Total protein was extracted with 20

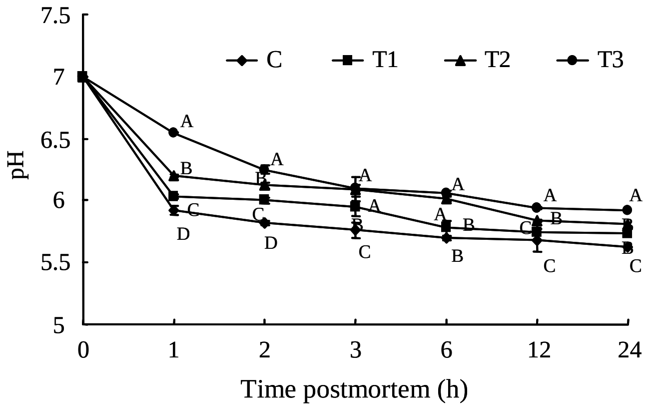

Figure 1. Changes in muscle pH by sodium bicarbonate injection during 24 h postmortem. C: Control. T1, T2, T3: Injected with 0.25 M, 0.40 M and 0.75 M sodium bicarbonate (2% w/w) respectively. [A, B, C] The pH values with different letters in same time postmortem are significantly different (p<0.05).

ml of ice-cold 1.1 M potassium iodide in 0.1 M phosphate buffer, pH 7.2 (Helander, 1961) which was added to duplicate 1 g samples. The same procedures for homogenization, shaking, centrifugation and protein determination were used as described above. Myofibrillar protein concentration was obtained by difference.

Shear force value

Cooked muscles were allowed to cool to 25°C and three 0.27 cm core samples oriented parallel to the muscle fiber structure of the meat were excised. Warner-Braztler shear force, perpendicular to muscle fiber orientation, was determined for each core using an Instron Universal Testing Machine (Model 1000) with a Load cell: 50 kg and Chart speed: 100 mm/min.

Na^+ concentration

Na^+ concentration was measured by the method of Hopkins and Thompson (2001) using DX-120 ion chromatography. A muscle sample (3 g) was added to distilled water (27 ml) and homogenized (IKA labortechnik T25-B, Malaysia) for 30 seconds. Homogenates were filtered with filter paper (Whatman #1) and the 0.2 μm MFS (micro filtration systems). The Na^+ concentration was determined using a DX-120 ion chromatography system (DX-120 ion chromatography, Dionex Corp, USA). The value of measurements was changed to ppm. A positive ion standard DIOEX P/N 43162 and 20 mM Methane Sulfonic Acid were used as Standard and fluent, respectively.

Palatability

A nine points hedonic scale was used by the panel for both fresh and cooked pork evaluation. For fresh pork, the following score limit was used: panel test scores of aroma (1-3: weak, 4-6: moderate, 7-9: strong), color (1-3: pale, 4-6: normal, 7-9: dark), off-flavor (1-3: weak, 4-6: moderate, 7-9: strong), drip (1-3: small, 4-6: moderate, 7-9: large) and acceptability (1-3: dislike, 4-6: moderate, 7-9: like).

For the cooked pork, the classification were: aroma (1-3: weak, 4-6: moderate, 7-9: strong), flavor (1-3: weak, 4-6: moderate, 7-9: strong), juiciness (1-3: small, 4-6: moderate, 7-9: large), tenderness (1-3: tough, 4-6: moderate, 7-9: tender), off-flavor (1-3: weak, 4-6: moderate, 7-9: strong) and acceptability (1-3: dislike, 4-6: moderate, 7-9: like) were tested.

Statistical analysis

The 4 treatments were taken randomly from 4 cuts of each pig. The data was analysed using statistical analysis systems (SAS, 1999). To evaluate the differences among treatments, data was analysed by analysis of variance (ANOVA) and Duncan's multiple range test was used to compare the means of different treatments.

RESULTS AND DISCUSSION

Changes in muscle pH

Changes in muscle pH by sodium bicarbonate injection are shown in Figure 1. The pH of sodium bicarbonate treated samples was significantly (p<0.05) higher than that of the control and sodium bicarbonate treated samples showed significantly (p<0.05) retarded pH decline pattern with increasing sodium bicarbonate injection levels. The results were in agreement with many authors (van Laack et al., 1998; Kauffman et al., 1998; Wynveen et al., 2001) who found increasing muscle pH in early postmortem with injection of sodium bicarbonate and phosphate. The retardation of pH decline in pork loin by injection of sodium bicarbonate could alter pork quality characteristics. The development of PSE is related to the rate and extent of postmortem glycolysis (Ledward, 1992). Therefore, it could

Table 1. Effect of sodium bicarbonate (SBC) injection (2% w/w) on objective meat color (CIE L^* a^* b^*) of porcine *longissimus muscle*

Treatments	L^* (Lightness)	a^* (Redness)	b^* (Yellowness)	Chroma (intensity)	Hue angle
Control	52.69±2.01 ^{A}	4.28±0.83 ^{C}	1.99±1.59	7.01±1.81 ^{A}	33.89±6.88 ^{A}
0.25 M-SBC	48.02±2.39 ^{B}	5.09±1.13 ^{AB}	2.00±1.29	5.55±1.38 ^{B}	19.78±10.89 ^{B}
0.40 M-SBC	47.56±2.34 ^{B}	4.51±1.13 ^{BC}	1.84±1.00	4.91±1.34 ^{B}	21.02±8.32 ^{B}
0.75 M-SBC	47.35±2.86 ^{B}	5.71±1.23 ^{A}	1.84±0.84	4.73±0.75 ^{B}	23.43±11.39 ^{B}

$^{A, B, C}$ Means±SD with different superscripts in the same column are significantly different (p<0.05).

Table 2. Effects of sodium bicarbonate (SBC) injection on drip loss, cooking loss and water-holding capacity (WHC) of porcine *longissimus muscle*

Treatments	Drip loss (%)	Cooking loss (%)	WHC (%)
Control	5.38±1.77 ^{A}	34.79±5.15 ^{A}	73.78±4.14 ^{C}
0.25 M-SBC	3.09±0.70 ^{B}	28.23±2.37 ^{B}	74.94±4.48 ^{BC}
0.40 M-SBC	2.65±0.46 ^{B}	23.98±1.39 ^{BC}	77.46±4.37 ^{AB}
0.75 M-SBC	2.98±0.52 ^{B}	21.51±3.53 ^{C}	79.27±4.78 ^{A}

$^{A, B, C}$ Means±SD with different superscripts in the same column are significantly different (p<0.05).

Table 3. Effects of sodium bicarbonate (SBC) injection on shear force value and sarcomere length of porcine *longissimus muscle*

Treatments	Shear force (kg/cm^2)	Sarcomere length (μm)
Control	5.13±0.85 ^{A}	1.77±0.23
0.25 M-SBC	4.96±0.48 ^{A}	1.66±0.25
0.40 M-SBC	4.01±0.91 ^{B}	1.62±0.27
0.75 M-SBC	3.23±0.84 ^{C}	1.67±0.18

$^{A, B, C}$ Means±SD with different superscripts in the same column are significantly different (p<0.05).

be possible that injection of sodium bicarbonate to pre-rigor *porcine longissimus* might prevent PSE development.

Changes in pork loin color

Effect of sodium bicarbonate injection on color of pork loin is shown in Table 1. The color of the sodium bicarbonate treated samples was darker than that of control, and it became darker with increasing sodium bicarbonate injection levels. Sodium bicarbonate treated samples showed significantly (p<0.05) lower lightness and higher redness values compared to the controls. These results are in agreement with Kauffman et al. (1998) and Wynveen et al. (2001), who showed that early postmortem injection of sodium bicarbonate was effective at preventing development of pale lean color. Crehan et al. (2000) also reported that the injection of sodium chloride solutions showed significantly (p<0.05) lowered the L* of pork loin. Sodium bicarbonate treated samples showed significantly (p<0.05) lower chroma and hue angle value. These results implied that the color of sodium bicarbonate treated samples was darker compared to the control.

This color change of pork loin was expected because researchers had shown that a strong positive relationship between color and pH of pork (Warner et al., 1997; Joo et al., 1999). PSE and DFD pork differ from normal pork in physiological and biochemical characteristics. The unusual pH and water-holding capacity of PSE and DFD muscles lead to unusual meat colors (Faustman and Cassens, 1990). In this study, the effect of sodium bicarbonate injection on muscle pH was dramatic and since the ultimate pH of sodium bicarbonate treated samples was significantly higher (Figure 1), the lower L* value was directly effected by sodium bicarbonate injection that resulted in dark color of pork..

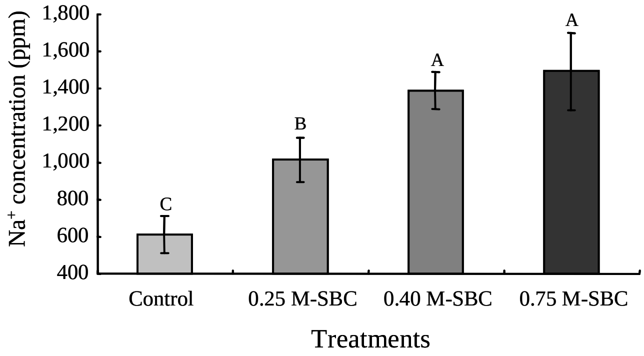

Figure 2. Effect of sodium bicarbonate (SBC) injection on Na^+ concentration of porcine *longissimus muscle*. $^{A, B, C}$ Means±SD with different superscripts are significantly different (p<0.05).

Water-holding capacity of pork loin

Effect of sodium bicarbonate injection on drip loss, cooking loss and WHC of porcine *longissimus muscle* are shown in Table 2. The drip loss of sodium bicarbonate treated samples was significantly lower (p<0.05) than that of the control at 24 h postmortem. The cooking loss of the sodium bicarbonate treated samples was significantly (p<0.05) lower than that of control, and it was significantly lower (p<0.05) with increasing of sodium bicarbonate injection levels. Also, the WHC of sodium bicarbonate treated samples was significantly (p<0.05) higher than that of control, and it was significantly higher (p<0.05) with increasing sodium bicarbonate levels.

Most of the concentration levels of sodium bicarbonate reduced the percentage drip and the results were similar to Kauffman et al. (1998). The data of drip loss proved the prior hypothesis that the sodium bicarbonate injection resulted in the less drip loss due to the high ultimate pH of muscle. The water binding improvements with the addition of sodium bicarbonate could be attributed to increases in muscle pH and ionic strength (Kauffman et al., 1998). Ionic strength could be related to the number of ions in solution, sodium bicarbonate increases the number of ions, which react with the protein and increase hydration.

When sodium bicarbonate was added to hot-boned meat, the water-binding ability was enhanced (Vosgen, 1993). Sheard et al. (1999) reported that addition of 0.3% and 0.5% polyphosphate to post-rigor pork loins improved WHC. Additionally many researchers have shown that polyphosphates, or their blends, when incorporated into further processed products such as sausages and restructured meat products to enhance WHC (Bernthal et al., 1991). The results of this study also suggested that sodium bicarbonate injection to pre-rigor pork muscle might be utilized to enhance the WHC of the final meat product.

Sarcomere length, shear force, Na^+ concentration and protein solubility of pork loin

Effects of sodium bicarbonate injection on shear force, sarcomere length and Na^+ concentration of porcine *longissimus muscle* are shown in Table 3 and Figure 2. The shear force of sodium bicarbonate treated samples was significantly ($p<0.05$) lower than that of control at 24 h postmortem. The sarcomere length was not affected by sodium bicarbonate injection. However, the Na^+ concentration of sodium bicarbonate treated samples was significantly ($p<0.05$) higher than that of control at 24 h postmortem.

Tenderness is a major palatability characteristic of meat. In this study, sodium bicarbonate injection was effective at reducing shear force. This result was similar to Wynveen et al. (2001), who reported that shear force of phosphate and sodium bicarbonate treated meat was less than their respective control. Similar results were found by many authors using tripolyphosphate injection in pork loin at different level (Smith et al., 1984; Sheard et al., 1999). According to Yasui et al. (1964), this tenderizing effect might be attributed to the fact that polyphosphates promote the weakening of the myosin heads to actin, and thus promote the dissociation of actomyosin. Therefore, in this study, the dissociation could allow more water to be retained or taken up by sodium bicarbonate treated samples. Data suggested that the increased tenderness might be attributed directly to the higher water content and weakened muscle structure.

Effect of sodium bicarbonate injection on protein solubility of porcine *longissimus muscle* is shown in Table 4. The myofibrillar protein and total protein solubility of sodium bicarbonate treated samples was significantly ($p<0.05$) higher than that of the control. However, no differences in sarcoplasmic and myofibrillar protein fractions among treatments in SDS polyacrylamide gel pattern were observed. Kauffman et al. (1998) reported an increase in protein solubility, and suggested that sodium bicarbonate reduced protein denaturation in muscles from halothane-sensitive pigs. According to Marta et al. (1999), myofibrillar protein solubility and sarcoplasmic protein solubility were dependent on meat quality and NaCl concentration. Joo et al. (1999) found that drip loss of pork was decreased if total protein solubility including sarcoplasmic protein solubility was increased. Thus, less drip loss and dark color of pork injected sodium bicarbonate might be due to increasing of myofibrillar and total protein solubility.

Palatability of fresh and cooked pork

Effects of sodium bicarbonate injection on panel test score of fresh and cooked pork loin are shown in Table 5 and Table 6. In the fresh meat, the panel test score for the color of sodium bicarbonate treated samples was significantly ($p<0.05$) tender than that of the control, and sodium bicarbonate samples showed better acceptability compared to control samples by panels. In the cooked meat, the tenderness score of sodium bicarbonate treated samples was significantly ($p<0.05$) higher than that of the control. Also the sodium bicarbonate samples showed better acceptability for cooked pork loin.

These results were similar to findings of several researchers. Wynveen et al. (2001) reported that the early postmortem injection of phosphate and sodium bicarbonate

Table 4. Effect of sodium bicarbonate (SBC) injection on protein solubility (mg/g) of porcine *longissimus muscle*

Treatments	Total protein	Sarcoplasmic protein	Myofibrillar protein
Control	204.34±13.6^{B}	77.6±7.8	123.8±13.2^{B}
0.25 M-SBC	219.30±16.7^{A}	79.±5.64	139.9±20.4^{A}
0.40 M-SBC	218.10±17.2^{A}	82.0±5.9	136.1±19.2^{AB}
0.75 M-SBC	219.63±17.3^{A}	79.1±7.9	140.5±18.0^{A}

$^{A, B}$ Means±SD with different superscripts in the same column are significantly different ($p<0.05$).

Table 5. Effect of sodium bicarbonate (SBC) injection on panel test score of fresh pork loin

Items	Treatments			
	Control	0.25 M SBC	0.40 M SBC	0.75 M SBC
Aroma	4.17±0.41	4.83±0.98	5.00±1.27	5.33±1.03
Off-flavor	4.83±1.47	4.33±1.37	4.50±1.52	3.67±1.03
Drip	4.17±0.98	4.00±0.89	3.50±1.05	3.50±1.05
Color	4.33±0.82^{B}	5.50±1.05^{AB}	5.67±1.03^{A}	5.67±1.03^{A}
Acceptability	4.33±0.82^{B}	5.50±0.84^{A}	5.67±0.82^{A}	6.17±0.75^{A}

$^{A, B}$ Means±SD with different superscripts in the same row are significantly different ($p<0.05$).

Aroma (1-3: weak, 4-6: moderate, 7-9: strong), color (1-3: pale, 4-6: normal, 7-9: dark), off-flavor (1-3: weak, 4-6: moderate, 7-9: strong), drip loss (1-3: small, 4-6: moderate, 7-9: large), acceptability (1-3: dislike, 4-6: moderate, 7-9: like).

Table 6. Effect of sodium bicarbonate (SBC) injection on panel test score of cooked pork loin

Items	Treatments			
	Control	0.2 M SBC	0.40 M SBC	0.75 M SBC
Aroma	5.25±0.50	5.00±0.82	5.00±0.82	4.75±1.50
Flavor	4.75±0.96	4.00±0.82	4.25±0.96	4.25±0.96
Off-flavor	3.75±1.26	2.50±1.29	2.50±1.29	2.75±1.50
Juiciness	4.25±0.96	4.25±0.96	5.00±0.82	5.50±0.58
Tenderness	4.75±0.96^{B}	5.00±0.82 ^{B}	6.00±0.82^{AB}	6.50±1.00^{A}
Acceptability	4.75±0.96^{B}	5.50±1.00^{AB}	6.00±0.82^{AB}	6.50±1.29^{A}

$^{A, B}$ Means±SD with different superscripts in the same row are significantly different ($p<0.05$).
Aroma (1-3: weak, 4-6: moderate, 7-9: strong), Juiciness (1-3: small, 4-6: moderate, 7-9: large), Tenderness (1-3 : tough, 4-6 : moderate, 7-9: tender), Flavor (1-3: weak, 4-6: moderate, 7-9: strong), Off-flavor (1-3: weak, 4-6: moderate, 7-9: strong), Acceptability (1-3: dislike, 4-6: moderate, 7-9 : like).

solutions prevented development of pale color. Also, pre-rigor injection of phosphate-based solutions has been shown to the darken color of both beef and turkey muscle (Young and Lyon, 1994). It can be stated that the sodium bicarbonate treated pork resulted in higher pH, color and acceptability than their controls in this study. Sheard et al. (1999) found that pork loins injected with 0.3% and 0.5% sodium tripolyphosphate were rated by a sensory panel as more tender and juicy than the control. Kauffman et al. (1998) also showed that pre-rigor SBC+NaCl injected samples had improved flavor and juiciness compared with the other treatments. According to Watanabe et al. (1996), early postmortem high pH was positively correlated with tenderness of meat. Therefore, better scores for tenderness and acceptability of sodium bicarbonate treated samples in this study might be due to high muscle pH, enhanced WHC and more dark color of pork loin.

CONCLUSIONS

Results of this study indicated that sodium bicarbonate injection to pre-rigor *M. longissimus lumborum.* of pork carcass could improve pork quality. It was clearly observed that muscle pH, meat color, water holding capacity, tenderness and protein solubility of pork loin were affected by concentration of injected sodium bicarbonate directly. The results also suggested that PSE pork occurrence could be reduced by injection of sodium bicarbonate before carcass chilling at the slaughter house.

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