THE EFFECT OF PRE-RIGOR APPLICATION OF SODIUM BICARBONATE ON THE QUALITY OF PORK

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INTRODUCTION

The process that causes pork muscles to become PSE is a critical combination of rapid pH decline and high muscle temperature. Thus, in an effort to prevent the development of PSE, either the temperature or the pH has to be 'changed'. In the past, research on PSE has concentrated on temperature. Only recently have researchers attempted to influence the acid-base balance in the muscle. Efforts to delay post-mortem pH decline by ante-mortem administration of sodium bicarbonate (SBC) have met with little success (Ahn et al. 1992; Boles et al. 1994). The more direct approach of pre-rigor SBC injection/perfusion seems more promising (Kauffman et al. 1994; van Laack et al. 1996); pre-rigor application of SBC resulted in an increase in pH and improved water-holding capacity (WHC).

Van Laack et al. (1996) used halothane-negative animals, heterozygous for the stress gene (Nn). None of the tested animals produced PSE. Thus, it was not possible to determine if the effect of SBC on color and water-holding capacity was large enough to reduce or totally prevent PSE. The present study was designed to determine the effect of SBC in halothane-positive (PSE-prone) animals. In addition, two means of SBC delivery, perfusion and injection, were evaluated.

MATERIALS AND METHODS

Ten Pietrain-type pigs, homozygous for the halothane gene, were used. Pigs were transported to the University one day before slaughter. The morning of the experiment, they were transported to the laboratory.

Each pig was electrically stunned, then bled for 10 min. Treatment side was chosen at random. At 5 min post mortem, one longissimus lumborum (LL) of each carcass was injected with approx. 300 ml 0.14 M SBC in 0.7% saline. The opposite side served as a control and was not injected. Subsequently, carcasses were opened at the central midline of the abdominal cavity. Perfusion via the iliac artery into the pelvic limb was initiated at 15 min post mortem. For each carcass, one pelvic limb was perfused with 4 liters of 0.75 M SBC in 0.7% saline. The opposite pelvic limb served as control. Perfusion required 10 min. At 24 h post mortem, quality of the treated and control LL and semimembranosus (SM) muscles was assessed.

Ultimate pH, expressible exudate, drip loss, surface color (L^*, a^*, b^*) and total protein solubility were assessed following procedures described by Warner (1994). A 50-100 g sample was frozen in liquid nitrogen, powdered and analyzed for total water content (AOAC, 1990), sodium (Soil and Tissue Analysis Laboratory, 1987), and lactate (Bergmeyer, 1974).

Data were analyzed using the paired comparison Student t-test.

RESULTS AND DISCUSSION

Perfusion of the semimembranosus muscle

SBC administration resulted in a significantly higher pH, lower L^* (darker color), increased protein solubility and lower drip losses (Table 1). Based upon the sodium content, it can be concluded that about 10% of the perfused SBC was absorbed. When perfusing halothane-negative/Nn pigs, we achieved only 5% absorption (van Laack et al. 1996). It is not clear what caused the higher absorption in the present study. Except for the difference in type of animals used, the two studies were similar. In the present as well as previous study, we observed large differences in SBC absorption between animals. Probably, factors such as capillary vascularization influence absorption.

The choice of SBC concentration was based upon results of previous studies. The aim was to increase pH but prevent DFD. The results of the present study indicate that it is difficult to control the amount of SBC that is absorbed. The higher than expected absorption in the present study resulted in an ultimate pH well above 6.0, e.g DFD meat.

Injection of the longissimus lumborum

The LL was injected with 0.14 M SBC. The choice of this concentration was based upon data from previous experiments with the SM and on tests with post-rigor pork. Assuming a 10% injection and 100% absorption, the pH increase was expected to be 0.15 to 0.2 units. As indicated above, a larger pH increase was undesirable as it could result in DFD. The sodium and moisture data indicate that we achieved the 10% injection. Yet, the effect on ultimate pH, though significant, was marginal.

The SBC-injected LL had a somewhat darker color, lower drip loss and higher protein solubility as compared to the control

(Table 1). Results indicate that a higher SBC concentration might be effective in reducing PSE.

The expectation was that the buffering effect of SBC would prolong the activity of glycolytic enzymes resulting in increased lactate production in SBC-treated muscle. However, lactate concentration of the SBC-injected LL was significantly lower than lactate concentration of the control. This suggests that SBC inhibited glycolysis. In previous studies, we have not observed such an inhibitory effect. Probably, the lactate in the SBC muscle was diluted by the added water. As can be seen in Table 1, the SBC treatment resulted in a higher moisture content. Taking into account this dilution, and assuming no effect of SBC on lactate production, it can be calculated that lactate concentration in the SBC-treated LL should be 94 μmol/g lactate.

Although all animals were halothane-positive, only 4 of the 10 animals developed PSE. Using the quality classification system described by Warner (1994), we improved the quality in 7 of the 10 cases; 2 PSE loins improved to RFN (Red, Firm and Non-exudative), 2 PSE to RSE (Red, Soft and Exudative), and 3 RSE to RFN. Two of the 3 RFN loins remained RFN and one RFN loin was converted to RSE.

CONCLUSION

The results of this study confirm that pre-rigor application of SBC may be an effective means to prevent PSE. Compared to perfusion, injection seems to be a better method of delivery. Injection is rapid and may be easier to control. Further studies to determine the SBC concentration required to reduce PSE but prevent DFD, and to determine the feasibility of injecting ham muscles, are underway.

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TABLE 1 QUALITY CHARACTERISTICS OF PORCINE SEMIMEMBRANOSUS (SM) AND LONGISSIMUS LUMBORUM (LL) AS AFFECTED BY PRE-RIGOR SODIUM BICARBONATE (SBC) PERFUSION (SM) OR INJECTION (LL), N=10.

	SEMIMEMBRANOSUS				LONGISSIMUS LUMBORUM			
	CONTROL		SBC		CONTROL		SBC	
Ultimate pH	5.50^{b*}	± 0.03	6.13^{a}	± 0.59	5.47^{b}	± 0.03	5.54^{a}	± 0.07
L*-value	44.9^{b}	± 2.2	40.1^{a}	± 2.3	48.7^{b}	± 2.7	46.0^{a}	± 1.9
Expressible fluid (mg)	63	± 25	54	± 26	83	± 47	67	± 17
Drip loss (%)	5.0^{b}	± 1.9	3.1^{a}	± 1.0	7.2	± 3.6	5.8	± 1.3
Protein solubility (mg/g)	174^{b}	± 33	198^{a}	± 10	167	± 41	182	± 20
Moisture (%)	75.2	± 0.4	75.4	± 1.3	75.1^{b}	± 0.6	77.5^{a}	± 0.8
Sodium (ppm dry weight)	1551^{a}	± 178	7839^{b}	± 5742	1180^{a}	± 329	2566^{b}	± 891
Lactate (μmol/g)	104	± 15	110	± 12	106^{a}	± 16	97^{b}	± 16

Within muscle, means with different superscripts are significantly different ($p<0.01$).