PE1.48 Use of blood lactate to measure swine handling stress from farm to processing plant: Relationship to pork quality 302.00

Lily Edwards (1) lilynedwards@gmail.com, Temple Grandin(1), Terry Engle 1, Andrzej Sosnicki 2 Jorge Correa 3 David Anderson 1

(1)Colorado State University, Department of Animal Sciences, Ft. Collins, CO, USA

(2)PIC, Hendersonville, TN, USA

(3)F. Menard, Ange-Gardien, Quebec, Canada

Abstract— Two studies were conducted to assess the impact of [LAC] on meat quality in two commercial slaughter plants. In Study 1, there were two experiments. Exp.1 used 80 market pigs, Exp. 2 used 144 pigs. Blood lactate was measured on each animal at the following locations during marketing: (1) farm baseline, (2) post-load at farm, (3) pre-unload at plant, (4) post-unload, (5) post-lairage, (6) post-movement to stunner and (7) at exsanguination. The sampling points with highest blood lactate were loading and exsanguination. Pearson correlations were used to determine relationships between [LAC] and meat quality. Increased [LAC] during loading at the farm resulted in improved meat quality, i.e. increased 24 h pH, decreased L* and decreased drip loss (P < 0.03) (Exp. 1 & 2). Exsanguination [LAC] was not related to meat quality (Exp. 1 & 2). In Study 2, 128 pigs were used. Blood lactate was measured at exsanguination. Pearson correlations were used to determine relationships between [LAC] and meat quality. Consistent with previously published reports, exsanguination [LAC] was negatively correlated to 60 min post-mortem pH (P = 0.0004) and positively correlated (P = 0.02) to drip loss. In conclusion, blood lactate concentrations during loading showed the most consistent relationship to meat quality, suggesting that high [LAC] during loading is associated with improved meat quality - higher ultimate pH, darker color, and lower drip loss. A negative relationship between exsanguination [LAC] and meat quality was found is Study 2, consistent with previously published reports, but not in Study 1. It is hypothesized that the contradictory results between studies may be due to: (a) the differential effects of mild vs. more aggressive pre-stunning handling on meat quality; and (b) opposing effects of handling stress at loading and exsanguination on meat quality.

Index Terms— animal handling, blood lactate, pre-slaughter handling, meat quality

I. INTRODUCTION

Physiological changes associated with immediate pre-slaughter stresses have been shown to have detrimental effects on pork quality [1,2,3,4]. One physiological change in swine associated with animal handling stress is an increase in blood lactate concentration ([LAC]) [5,6]. Hambrecht and coworkers [3,4] explored the relationship between high exsanguination [LAC] and pork quality and determined that swine with higher [LAC] at slaughter result in pork with higher drip loss. Warriss et al. [7] were able to demonstrate a correlation between the subjective assessment of stress level and the objective measures of stress and meat quality in a survey study of swine slaughter plants; high stress was associated with high exsanguination [LAC] and lower meat quality. The objective of these studies was to determine if a relationship existed between pre-slaughter animal handling, not only immediately prior to stun but from the farm to the meat processing plant, and meat quality.

II. MATERIALS AND METHODS

Two studies were conducted separately to assess the impact of [LAC] on meat quality in two different commercial slaughter plants.

Study 1

Study I was conducted at a processing plant in the Midwest United States. Two experiments were conducted, differing in season, facility design and experimental protocol. Exp. 1 used 80 market weight pigs (125 ± 9 kg, mean ± SD) and Exp. 2 used 144 pigs (128 ± 3 kg, mean ± SD). Briefly, animals were transported from the finisher barn approximately 2.5 h to a slaughtering facility. At the facility, pigs were unloaded, rested, electrically stunned and exsanguinated. During the marketing

process, [LAC] was measured on each animal at seven different sampling points: (1) baseline at the farm, (2) post-load on the truck, (3) pre-unload on the truck, (4) post-unload in the pen, (5) post-lairage, (6) post-movement to stunner and (7) exsanguination. A low-stress sampling technique was used. A 20 gauge needle was used to prick a distal ear vein. A drop of blood was analyzed with a hand-held lactate analyzer (Lactate Scout, EKF Diagnostics GmbH, Magdeburg, Germany). The following meat quality measurements were obtained on each animal following slaughter: 45 min pH, 24 h pH, visual color, Minolta color, 24 h drip loss and glycolytic potential. Pearson correlations were used to determine the relationships between [LAC] obtained at all sample points and meat quality parameters.

Study 2

Study 2 was conducted at a processing plant in Quebec, Canada. In this study, 128 pigs, which had been on a previous feeding trial, were used (127 + 9 kg, mean + SD). Briefly, feed was withdrawn from test pigs approximately 10 hrs prior to transport. Pigs were transported 1 hr to the slaughter plant, rested overnight, stunned with carbon dioxide and exsanguinated. An exsanguination blood sample was collected and analyzed with a hand-held lactate analyzer (Lactate Scout, EKF Diagnostics GmbH, Magdeburg, Germany). The following meat quality measurements were obtained on each animal following slaughter: 60 min post-mortem pH, ultimate pH (24 h), visual color (Japanese color standard), Minolta color, 48 h drip loss and glycolytic potential. Pearson correlations were used to determine the relationships between exsanguination [LAC] and meat quality.

III. RESULTS AND DISCUSSION

Study 1 Blood lactate changed during the marketing process ($P < 0.0001$) Figure 1. The highest [LAC]s were observed at loading and exsanguination, emphasizing the focal points for improved animal handling (Figure 1). Exsanguination [LAC]s were on the low end of previously reported values, reported values ranging from 4.4 to 31 mM [1,3,7]. Although results indicated that ultimate meat quality was related to physiological measures throughout the marketing process, [LAC] as a result of loading at the farm had the strongest relationship to meat quality. Results in both experiments indicate that [LAC] increased during loading. With increases in [LAC] post-loading (Table 1) and larger changes in [LAC] during loading (Table 2), meat quality improved. Increases in [LAC] were related to an increase in 24 h pH ($P = 0.01$ to 0.0001), a decrease in L* ($P = 0.12$ to 0.001), a decrease in drip loss ($P = 0.04$ to 0.002) and a tendency towards increased visual color score ($P = 0.07$ to 0.09 Exp. 1). There was a tendency for [LAC] at loading to be positively correlated to glycolytic potential ($P < 0.14$) in both experiments (Table 1). It is likely that physical exertion during loading reduced muscle glycogen. In these experiments, exsanguination [LAC] was not related to meat quality parameters as in previously reported research [1,3] (Table 3). Study 2 Exsanguination [LAC] was negatively correlated to 60 min pH ($r = -0.32$, $P = 0.0004$) and positively correlated ($r = 0.21$, $P = 0.02$) to drip loss (Table 3). These results suggest that exsanguination [LAC] is predictive of the rate of early post-mortem metabolism, i.e. high [LAC] predicts a rapid drop in early post-mortem pH resulting in greater drip loss. Previously published studies report that increased exsanguination [LAC] was indicative of accelerated early post-mortem metabolism resulting in greater drip loss [1,2,3]. In Study 1, this relationship was not observed. This may be due to the correlation between [LAC] at loading and [LAC] at exsanguination ($r = 0.37$, $P = 0.001$, Exp.1; $r = 0.18$, $P = 0.03$, Exp.2) indicating that animals with high [LAC] at loading tended to be the same animals with high [LAC] at exsanguination. It is postulated that the effects of loading on [LAC] and meat quality override any effects on early post-mortem metabolism reflected in exsanguination [LAC]. If a pig experiences both high [LAC] at loading (reduced muscle glycogen and higher ultimate pH) and high [LAC] at exsanguination (rapid post-mortem metabolism), it can be speculated that effects at loading (improved meat quality) may predominate. Additionally, the pigs in this study had generally lower [LAC] values than those observed in previous reports [1,2]. Perhaps the impact of exsanguination [LAC] on pork quality is most apparent in high stress handling systems. In Study 2, the mean exsanguination [LAC] values were similar to Study 1 and the handling prior to slaughter was very gentle. Despite these similarities to Study 1, the negative effect of high [LAC] on meat quality was observed; as exsanguination [LAC] increased, drip loss increased. In this experiment, animals were handled very gently at loading. The animals were

loaded using a flat ramp into a trailer with hydraulic lifts to lift the top deck. In addition, electric prods were not used. Additionally carbon dioxide stunning was used instead of electrical stunning potentially accounting for some difference.

IV. CONCLUSION

The data from Study 1 suggest that higher blood lactate concentrations during loading have a positive effect on meat quality (higher ultimate pH, darker color, and lower drip loss). Therefore, improving handling at the farm during loading will not necessarily translate to direct improvements in fresh pork quality traits. The data from Study 2 are consistent with published data showing that higher exsanguination [LAC] has a negative effect on meat quality (rapid early post-mortem metabolism and increased drip loss). In Study 1, the negative effect of exsanguination [LAC] on meat quality was not observed. These studies indicate an interesting potential interaction between [LAC] at loading and [LAC] at exsanguination. In Study 1 an increase in [LAC] during loading due to physical exertion up a steep ramp and handling, was demonstrated to have a positive impact on meat quality. Exsanguination [LAC] did not have the negative relationship to meat quality that has been previously published. We hypothesize that the increase in [LAC] early in the marketing process and the resultant increase in ultimate muscle pH, as well as gentle animal handing in the stun chute, resulted in the lack of effect of exsanguination [LAC] on meat quality. However, when animals are handled very gently during loading (Study 2), the published negative relationship between exsanguination [LAC] and meat quality was observed even with gentle handling in the stun chute. We hypothesize that non-aggressive loading will result in the expected negative relationship of exsanguination [LAC] and meat quality even when the handling is gentle at the slaughter facility. Additionally, as handling improves at the farm, the importance of maintaining low [LAC] at exsanguination through careful animal handling will likely have a greater impact on meat quality.

ACKNOWLEDGEMENTS

The authors would like to thank all the students and faculty members that helped conduct these experiments. This research was supported in part by grants from the Elanco Animal Health, Greenfield, IN and Quebec, Canada and PIC, Hendersonville, TN. Appreciation is also extended to the participating commercial packing facilities.

REFERENCES

[1] Hambrecht, E., J. J. Eissen, D. J. Newman, C. H. M. Smits, L. A. den Hartog, and M. W. A. Verstegen. 2005. Negative effects of stress immediately before slaughter on pork quality are aggravated by suboptimal transport and lairage conditions. J. Anim. Sci. 83: 440-448.

[2] Hambrecht, E., J. J. Eissen, D. J. Newman, C. H. M. Smits, M. W. A. Verstegen, and L. A. den Hartog. 2005. Preslaughter handling effects on pork quality and glycolytic potential in two muscles differing in fiber type composition. J. Anim. Sci. 83: 900-907.

[3] Hambrecht, E., J. J. Eissen, R. I. J. Nooijen, B. J. Ducro, C. H. M. Smits, L. A. den Hartog, and M. W. A. Verstegen. 2004. Preslaughter stress and muscle energy largely determine pork quality at two commercial processing plants. J. Anim. Sci. 82: 1401-1409.

[4] Warriss, P. D., S. N. Brown, T. G. Knowles, J. E. Edwards, P. J. Kettlewell, and H. J. Guise. 1998. The effect of stocking density in transit on the carcass quality and welfare of slaughter pigs: 2. Results from the analysis of blood and meat samples. Meat Sci. 50: 447-456.

[5] Anderson, D. B., D. J. Ivers, M. E. Benjamin, H. W. Gonyou, D. J. Jones, K. D. Miller, R. K. McGuffey, T. A. Armstrong, D. H. Mowrey, L. F. Richardson, R. Seneriz, J. R. Wagner, L. E. Watkins, and A. G. Zimmermann. 2002. Physiological responses of market hogs to different handling practices. Page 399-400 in Proceedings of the American Association of Swine Veterinarians 33rd Annual Meeting, Kansas City, MO.

[6] Benjamin, M. E., H. W. Gonyou, D. J. Ivers, L. F. Richardson, D. J. Jones, J. R. Wagner, R. Seneriz, and D. B. Anderson. 2001. Effects of animal handling method on the incidence of stress responses in market swine in a model system. J. Anim. Sci. 79 (Suppl.1): 279. (Abstr.).

[7] Warriss, P. D., S. N. Brown, S. J. M. Adams, and I. K. Corlett. 1994. Relationships between subjective and objective assessments of stress at slaughter and meat quality in pigs. Meat Sci. 38: 329-340.

[8] Edwards, L. N. 2009. Understanding the relationships between swine behavior, physiology, meat quality and management to improve animal welfare and reduce in-transit losses within the swine industry, Colorado State Univ., Fort Collins.