Influence of muscle conformation and animal maturity on brine distribution in moisture enhanced pork (MEP)

B. Uttaro, J. L. Aalhus, M. McLaughlin
Agriculture and Agri-Food Canada
6000 C & E Trail, Lacombe, AB T4L 1W1

Introduction

Previous work has suggested that intramuscular connective tissue has a significant impact on brine distribution in post-rigor meat (Uttaro & Aalhus, 2005). Rowe (1974) reported that the perimysium which surrounds muscle fiber bundles is composed of a lattice of connective tissue fibers oriented at an angle to the long axis of the muscle fibers. When muscle is contracted the connective tissue has a crimped, loose appearance and the angle in relation to the muscle fiber is large, but when the muscle is stretched both the crimp and the angle of connective tissue fibers in relation to muscle fiber decrease. Previously seen spaces in the perimysium are also no longer evident. Therefore the state of muscle contraction markedly alters connective tissue architecture. This can have a large influence on tenderness and textural properties of meat (Aalhus et al., 1999; Thompson, 2002). Increasing animal age is known to be associated with increasing strength and rigidity of collagen fibers (Bailey and Light, 1989) and incidence of insoluble pyridinoline crosslinks in the connective tissue (Shimokomaki et al., 1972), while within a species and breed, animals of similar ages and growth rates show minimal variation in degree of crosslinking (Avery et al., 1996).

This work was undertaken to test the hypothesis that a change in connective tissue architecture and/or permanent crosslinks of the intramuscular connective tissue would influence the distribution of an injected salt and phosphate brine.

Methods

Ninety-one barrows and gilts from Large White (LW) x LW and Duroc (D) x LW crosses were raised to either 77 kg or 117 kg, slaughtered in a conventional manner, graded, then cooled for 24 hrs at 2°C. Immediately following grading the right side of each carcass was suspended by the aitch bone and the rear foot tied to the front leg with enough tension to bring the front leg parallel to the floor. This resulted in a consistent degree of pre-rigor stretch to the back (*longissimus dorsi* - LD) and eye of the round (*semitendinosus* - ST) muscles (Fig 1). The left side remained suspended in the conventional manner, from the Achilles tendon, resulting in pre-rigor shortening of the LD and ST. Following carcass cooling and dissection of both muscles from each side of the carcass, paired muscles were weighed then injected to 108% by weight with a dyed salt and phosphate brine (4.8% salt, 4.8% sodium tripolyphosphate, 200 ppm FDC Blue #1). Meat was drained for 15 min, reweighed, then permitted to equilibrate overnight at 2° C. Each muscle was weighed a third time then cut open longitudinally, perpendicular to injection sites, and photographed (Fig 2). Images were then analyzed with Image J (available at http://rsb.info.nih.gov/ij; developed by Wayne Rasband, National Institute of Health, Bethesda, MD) for the % of the exposed surface that was blue (% blue), and the % of the injected area that showed poorly distributed brine (PDB). Brine distribution patterns were noted.

Results & Discussion

<u>Effects of suspension/muscle conformation:</u> Both stretched LD and stretched ST held significantly more brine than their unstretched counterparts (Fig 3a), and it is likely that this greater brine uptake contributed to the higher % blue (Fig 3b) and lower % PDB (Fig 3c) found for this treatment. Stretched muscle has long sarcomere lengths (SL) and a smaller diameter than contracted muscle. The longer SL provides more binding sites for the injected brine, possibly partially accounting for the higher pump levels seen. Another contributing

factor may be that the left and right hand muscles of each carcass were injected side-by-side. Contracted muscle has a greater diameter than stretched muscle, therefore the contracted muscle of the pair would have borne most of the pressure exerted by the stripping plate of the equipment during injection. This external pressure likely caused the pressure within the column of meat directly beneath the contact site of the stripping plate to exceed the pressure of the brine being injected, thereby reducing the amount of brine entering the meat in this area, and contributing to lower injection levels and so poorer brine distribution.

Observation of brine distribution patterns, particularly in regions which were not directly influenced by the pressure from the stripping plate, showed that brine consistently followed fibers away from the injection site, creating stripes or streaks where adjacent fibers either contained, or were free of brine. Stripes were more pronounced in stretched muscle, suggesting intramuscular connective tissue architecture contributed to decreases in lateral brine distribution.

Animal age: There were no age by suspension interactions. Heavy animals were on test approximately 36 d longer than light animals. Injected LDs from heavier, older hogs showed more extensive and better brine distribution (higher % blue and lower % PDB, respectively; Figs 3b and 3c) than those from lighter, younger animals even though injection levels (% pump) were similar (Fig 3a). In contrast, STs from heavier hogs held proportionally less brine than STs from light hogs and although % blue was higher, distribution was poorer. Brine distribution patterns in this muscle consistently showed marked stripes from end to end of the muscle suggesting brine was being permitted to move longitudinally along fibers but not laterally from the injection site.

The response of both muscles is consistent with an increase in connective tissue rigidity and cross-links with age. The difference in response between the two types of muscles may be due to the differing types of connective tissue present. In beef carcasses, the ST has the highest level of elastin (approximately 40% of the connective tissue), while the LD has very little (< 5%) (Bendall, 1967). The literature reveals little concerning the amount of elastin in different pork muscles, but it is likely that a similar relationship exists.

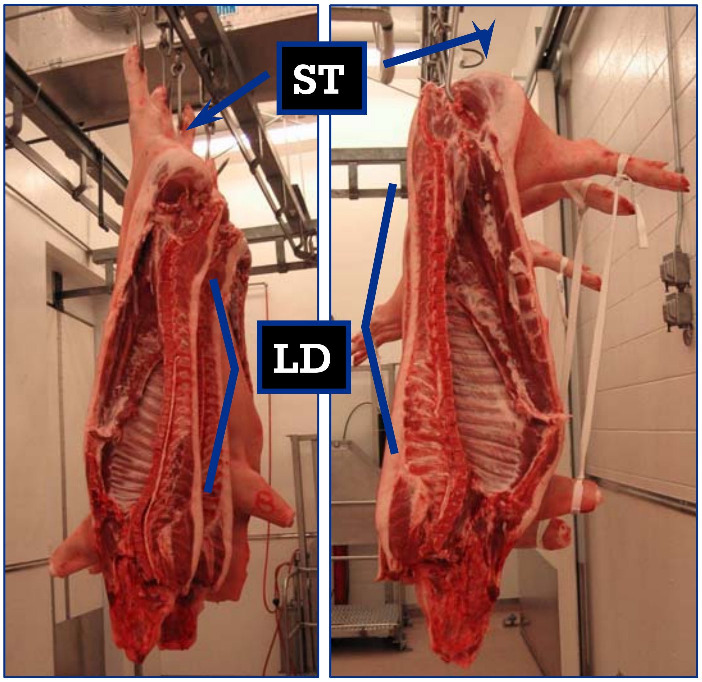
Breed: Extent of brine distribution, as interpreted from % blue, was significantly greater in LW x LW offspring than in D x LW offspring (61.5% vs 54.3%, $P \leq 0.0001$), although brine uptake and % PDB were similar.

Conclusion

Addition of tension to the connective tissue matrix appeared to contribute somewhat to changes in brine distribution. Effects were overshadowed by the influence of paired muscles of different thicknesses being injected together. Connective tissue maturity, and by extension the number of mature connective tissue crosslinks, had a positive influence on brine distribution along fibers.

References

Aalhus et al. (1999) Canadian Journal of Animal Science 79:27-34.
Avery et al. (1996) Meat Science, 42(3):355-369.
Bendall (1967) Journal of the Science of Food and Agriculture 18, 553-558.
Bailey and Light (1989) Connective Tissue in Meat and Meat Products. Elsevier Science Publishers, New York.
Rowe (1974) J. Fd Technol. 9:501-508.
Shimokomaki et al. (1972) Journal of Food Science 37:892-896.
Thompson (2002) Meat Science 62:295-308.
Uttaro & Aalhus (2005) Proceedings 51st International Congress of Meat Science and Technology, Baltimore, Maryland, August 2005, p536-539.

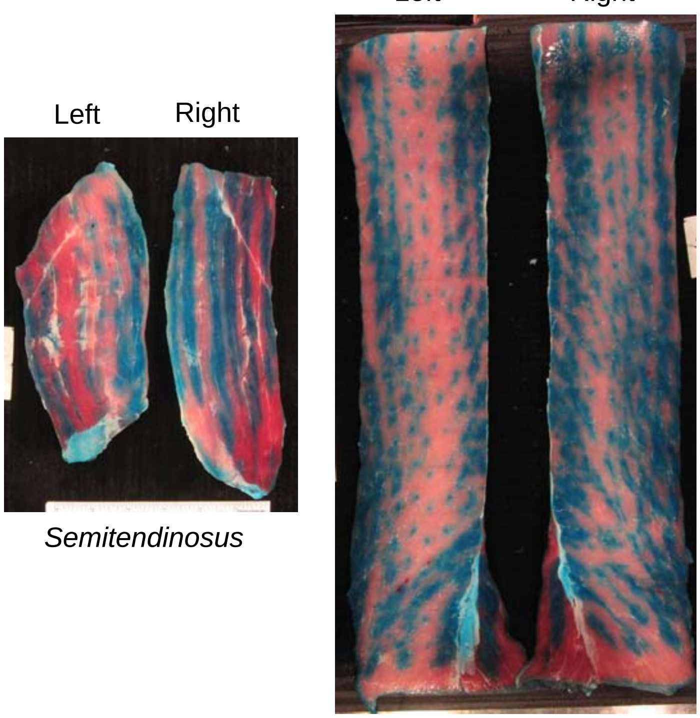


Left side Right side

Figure 1: Two suspension methods. Left sides suspended conventionally, resulting in pre-rigor shortening of ST (semitendinosus) and LD (longissimus dorsi) muscles. Right sides suspended by aitch bone and legs tied together to bring front leg parallel to floor resulting in pre-rigor stretching of ST and LD.

Left Right

Left Right



Semitendinosus *Longissimus dorsi*

Figure 2: Longitudinal axes, perpendicular to direction of injection needles on left and right sides of ST and LD. Blue dye in the brine made distribution of brine in the middle of the muscles easy to determine.

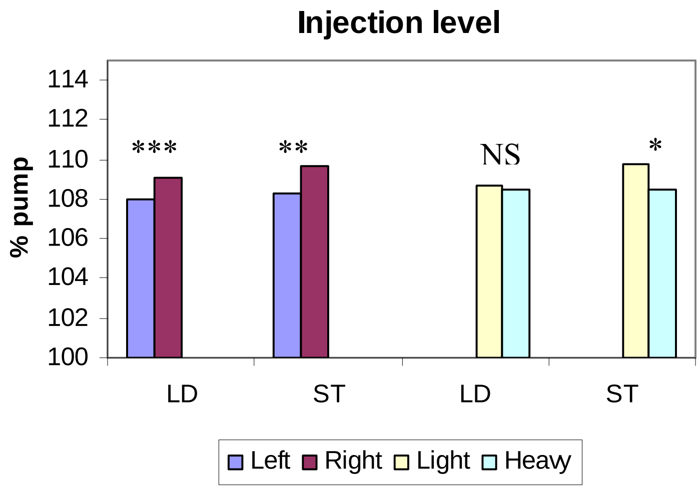


Figure 3a: Injection levels achieved in paired contracted (left side) and stretched (right side) *longissimus dorsi* and *semitendinosus* from light and heavy hog carcasses.

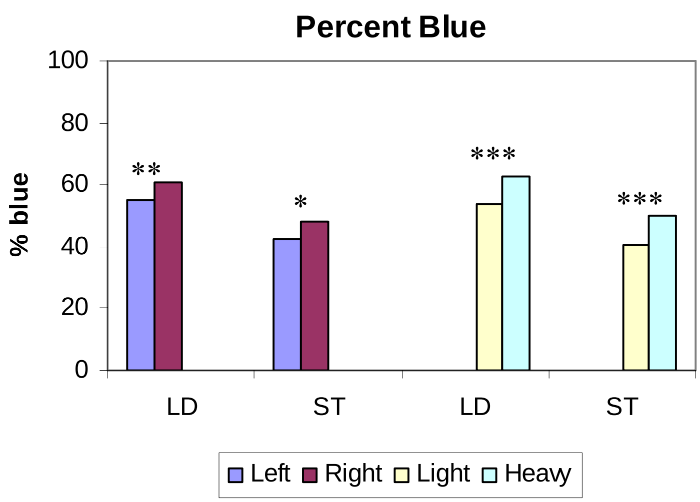


Figure 3b: Percent of mid-muscle cross-sectional area containing brine as evidenced by presence of blue colour.

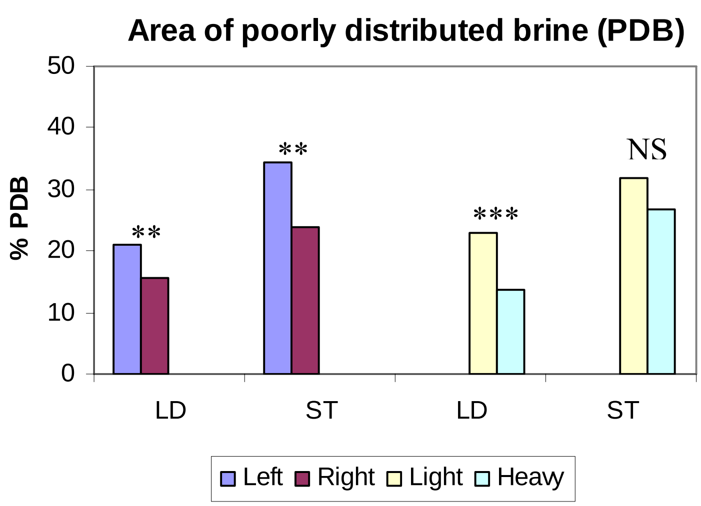


Figure 3c: Percent of mid-muscle cross-sectional area with poor brine distribution as evidenced by little and localized blue colour.

NS: non-significant; *: $P \leq 0.05$; **: $P \leq 0.005$; ***: $P \leq 0.0001$