EFFECT OF THAWING RATE ON DISTRIBUTION OF AN INJECTED SALT AND PHOSPHATE BRINE IN BEEF

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Introduction

The problem of striping in injected meat products has been noted in the literature repeatedly over the decades. It was seen first in cured products and was solved using post-injection tumbling. Today, striping is a problem in moisture enhanced meats such as beef and pork. These products are injected at low levels (108-112%) and generally do not undergo a tumbling treatment because the product is marketed raw and must still appear desirable in the retail case. There have been some suggestions made and equipment constructed to change the manner in which meat is injected, in order to minimize striping, yet the problem still exists. Possibilities for the effect that non-nitrite-/ate-containing brines have on meat colour have been postulated, and preferential brine movement from the injection site, along muscle fibre long axes, has recently been reported, confirming recent speculation. Since there is evidently something about the internal structure of the meat which restricts brine flow, a pre-injection treatment which disturbs this structure but which minimally changes the external appearance would be useful. Freezing and thawing rates have been known to affect internal meat structure to varying degrees through cellular disruption by ice crystal formation.

Objectives

There were two objectives in this research, firstly, to determine the brine distribution path in beef after injection. Secondly, to determine if the beef packers' practice of freezing excess boxed meat for a time may be beneficial to brine distribution once thawed meat is injected.

Methodology

Ribeyes (*longissimus thoracis*, LT) and eye of rounds (*semitendinosus,* ST) were collected from the right side of chilled carcasses of market weight Angus-cross steers. Meat was trimmed of all fat, vacuum packed, and aged at 3°C for a week. Two thirds of the samples of each muscle type were then frozen (-35°C) for a month. The other third was injected on an InjectStar® "New Twist" BI-72 with two rows (50% offset) of single 4mm-diameter needles spaced 2.5cm apart. Brine pressure was 1.5-2 bar and head speed was 60 strokes/min for LT's and 44 strokes/min for ST's. LT's were oriented dorsal surface upward for injection, and ST's were placed rounded surface upward. Injection was to 108-110% of initial muscle weight. Brine composition was 4.8% salt, 4.8% sodium tripolyphosphate, 200ppm FDC Blue #1, and reverse osmosis water. Injected samples were stored on trays at 3°C overnight, then cut to expose four faces and photographed for image analysis to determine the percentage of blue area. Faces were: 1) parallel to (and along) injection needle sites, 2) perpendicular to needles, 3) parallel to fibres, and 4) perpendicular to fibres. Fibres in the ST run parallel to the length of the muscle instead of diagonally as in the LT, therefore in the ST one cut exposed both faces 1 and 4, and a second cut exposed faces 2 and 3. Of the frozen samples, half were thawed slowly at 3°C in air over two days, the other half were thawed quickly in 12-17°C water over 5 hours. All then underwent the same injection process as the fresh samples.

Results & Discussion

Table 1 summarizes brine injection levels by muscle and treatment. There were no significant differences.

Subjective observations of exposed faces revealed a number of consistent features within each muscle type across all treatments. See Figures 1 and 2 for reference. On Face 1 (parallel to needles) of the LT, brine was found to be deposited in the top 2/3 to 3/4 of the muscle, and in many cases there were blue stripes with the same spacing as needles. These

were fairly clearly visible near the center of the face indicating poor lateral brine distribution here, while nearer to the edges they became blurred, indicating better brine distribution. Brine appeared to be fairly consistently injected throughout the needle path as was evidenced by uniform thickness of the blue bands. Faces 3 (parallel to fibres) and 4 (perpendicular to fibres) very clearly showed preferential movement of brine in fibre direction. Face 3 showed individual penetration sites by blue dots often near the center of the face, indicating minimal brine deposition, whereas the edges to either side appeared quite blue, often in somewhat blurred fine stripes that followed fibre direction. Face 4 showed areas of blue limited by intramuscular connective tissue, likely the perimysium. This applied to brine movement both within and between muscle fibre bundles. In the former case, brine appeared to be restricted within the bundles whereas in the latter case brine between bundles appeared to continue to move between groupings in preference to moving far into adjacent bundles. In several samples this movement along fibres was particularly well-illustrated through the contrast between Faces 1 and 3, for although needle entry depth was clearly only 2/3 of meat depth on Face 1, Face 3 showed dyed brine along the full length of the fibres. Face 2 (perpendicular to needles) consistently showed that the best brine distribution was along muscle edges, while the poorest was at the center of the cranial end.

On Face 1 & 4 of the ST, needle penetration depth was similar to the LT, and lateral brine movement (ie across fibre bundles) was clearly shown to be limited. Injection sites in the form of clear blue lines were obvious, particularly near the center of the sample. On Face 2 & 3, best brine distribution was at the edges of the muscle. The poorest, as evidenced by blue dots or even just holes where needles entered, was generally in a band just off-center of the longitudinal axis. Preferential movement of brine along muscle fibres was evident. There is a transverse band of connective tissue in the ST, and in a number of cases, this was clearly a barrier to longitudinal brine movement. In both the LT and ST, fat tissue was unaffected by brine injection and there was little evidence of opportunistic brine movement along the edges of fat deposits. In cases where needles pierced vascular tissues, brine entered, but did not seem to continue into muscle tissues at distant points, possibly because of insufficient brine pressure.

Strongly characteristic of both muscles, although to differing degrees, was the virtual lack of brine in the centre portions. This was likely due to the inevitably uneven pressure exerted by the stripper bar (a single piece, on this equipment) on a meat sample of non-uniform height. A greater intramuscular pressure builds under the high points of the sample on which the bar is pressing, than under the low points where pressure is lower. Internal meat pressure under the high points appears to be greater than brine pressure so little or no brine can enter the tissue. Equipment does exist in which the stripper bar is reduced to a series of stripper blocks, possibly with the aim to minimizing this problem.

The effect of thawing rate is presented in Table 2. Lack of significance in the percentage of area dyed blue across treatments within a face shows that neither a fast thaw nor a slow thaw treatment affected brine distribution. Since thaw treatment would be expected to disrupt the intrafascicular structure, this null effect offers evidence that lateral brine movement is restricted in some manner by the connective tissue.

Conclusions

In LT and ST samples injected to approximately 110%, direction of brine movement appeared to be governed by intramuscular connective tissue, causing brine to run lengthwise within or between muscle bundles more readily than across them. Also, in areas where pressure within the muscle could have exceeded brine pressure, brine was unable to penetrate. The cellular disruption caused by different thawing rates did not affect the extent of brine distribution, providing evidence that intramuscular connective tissue may play a significant role in restricting brine movement.

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Tables and Figures

Table 1: LSMeans of injection levels in LT's and ST's across three thawing regimes

		LT			ST	
Treatment	n	(% pump)	SE	n	(% pump)	SE
Non-frozen	6	109.5	0.603	12	109.5	0.973
Fast Thaw	9	108.93	0.492	13	110.8	0.935
Slow Thaw	12	108.98	0.426	12	109.99	0.973

Table 2: LSMeans of brine coverage (% blue) on each face of LT's and ST's across three thawing regimes.

	LT						ST			
	Face*						Face			
Treatment	n	1	2	3	4	SE	n	1 & 4	2 & 3	SE
% Blue										
Non-frozen	6	29.4	50.7	42.7	50.8	3.4	12	28.2	54.2	3.5
Fast Thaw	9	34.0	46.9	41.6	43.7	2.9	13	34.1	51.4	3.4
Slow Thaw	12	35.5	46.9	49.0	46.4	2.4	12	32.2	50.5	3.5

* Face 1= parallel to needles; 2 = perpendicular to needles; 3 = parallel to fibres; 4 = perpendicular to fibres

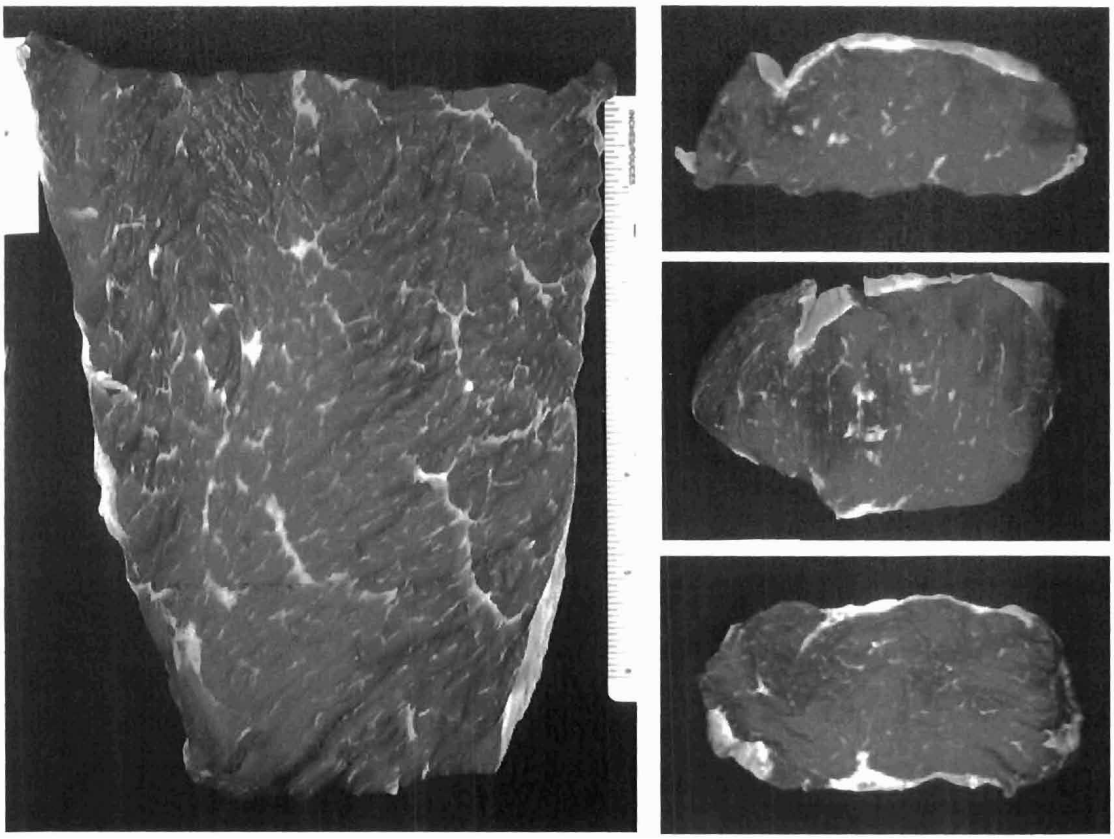

Figure 1: LT injected to 109.4%. Face 1, upper right: parallel to needles. Face 2, left: perpendicular to needles. Face 3, center right: parallel to fibers. Face 4, bottom right: perpendicular to fibers

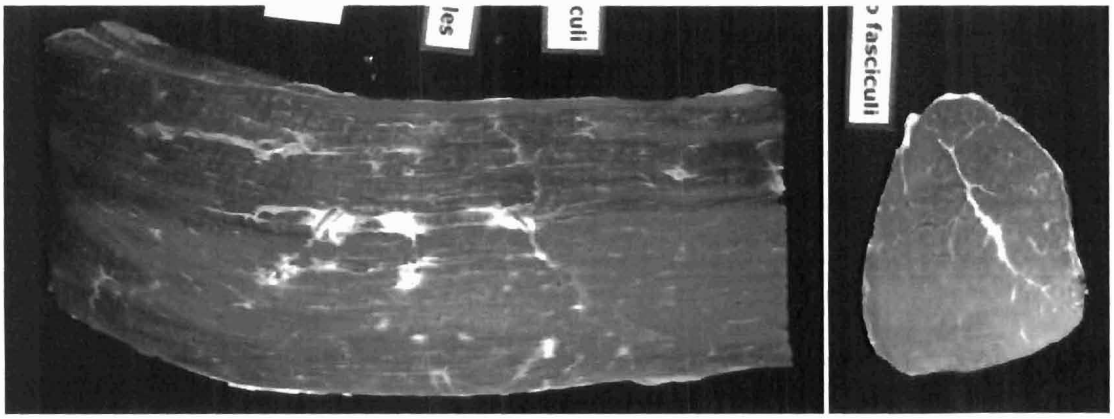

Figure 2: ST injected to 8.6%. Faces 2 and 3, left: perpendicular to needles and parallel to fibers. Faces 1 and 4, right: parallel to needles and perpendicular to fibers.