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EARLY POST-MORTEM ENHANCEMENT COUPLED WITH ACCELERATED CHILLING TO IMPROVE PORK QUALITY

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Introduction

With the incidence of pale, soft, and exudative (PSE) pork still prevalent in the pork supply and causing significant losses (Benchmarking Value in the Pork Supply Chain, 2003), ways to combat this problem both ante- and post-mortem are being explored. One such method is the use of accelerated chilling (i.e.: blast chill, spray chills, emersion in super chilled solutions, etc.). While this method has shown mixed results, the increased rate of temperature decline can lead to improved loin quality (Crenwelge, et. al., 1984; Weakley, et. al., 1986; Ohene-Adjei, et. al., 2003)

Enhancement technology in whole muscle cuts has seen an increase since initial work done in the 1980's (Smith, et. al., 1984). Initially brines would include salt and phosphates, but today lactates, flavorings, and other compounds are common. These brine solutions have been shown to help improve color, decrease purge loss, and improve sensory attributes (Banks, et. al., 1998; Detlenne and Wicker, 1999; Sheard, et. al., 1999; Prestat, et. al., 2002).

While both accelerated chilling and enhancement have been studied, the coupling of these two technologies has minimal research.

Objectives

The purpose for this study was to evaluate the effects of enhancement early post-mortem, coupled with accelerated chilling and to determine if these treatments will have an additive effect when evaluating a variety of quality measurements.

Methodology

A total of 16 pigs were harvested over two days. At 1 h post-mortem (accelerated chilling) the loin from the right side was excised and cut into two sections (anterior and posterior). These loin sections were alternately assigned to enhancement with a 0.4% salt, 0.4% phosphate, and 2.5% lactate in the finished product at 112% of green weight (Brine Temp ≈4°C). Once the loin section was enhanced, both sections were vacuum packaged and submerged in a super-chilled solution (starting temp. of -27°C) for 1 h. At 24 h post-mortem, the loin from the left side was removed and cut into two sections. The corresponding section to the right side was enhanced with the same brine. All sections were vacuum packaged and stored at 4°C until 10 d post-mortem.

At 10 d post-mortem, vacuum bags were opened and loin sections removed to determine percent purge loss. From each loin section, a chop was removed from the face of the loin to expose a fresh surface for evaluation. After 15 min of "bloom", subjective scores for color and marbling (NPPC, 1999), firmness (NPPC, 1991), and striping (Gooding, 2003) were evaluated. Objective measurements for color using a Minolta Chromameter CR-300 (Minolta Camera Co., Japan, illuminant D65 and 0° observer) were recorded. Lastly, pH was measured using an SFK Star Probe (SFK Technologies, Cedar Rapids, IA).

After evaluation, 2.5 cm chops were cut for Warner-Bratzler shear force determination and trained sensory analysis. Once cut, these chops were vacuum packaged and frozen at -30°C until the aforementioned tests could be conducted. Chops for the trained sensory panel were allowed to thaw at 4°C, trimmed to a uniform size, and cooked on a Farberware open hearth grill (Model 455N, Walter Kidde, Bronx, NY). Chops were cooked to an internal temperature of 70°C, before being served to a six member trained panel. Panelists evaluated samples for juiciness, tenderness, and off-flavor using a 15 cm anchored unstructured line scale (0 = extremely tough, extremely dry, and no off-flavor; 15 = extremely tender, extremely juicy, and extreme off-flavor).

Chops for Warner-Bratzler shear force were treated in the same fashion as that for sensory analysis. After cooking, chops were allowed to cool to 25°C before four, 1.3 cm cores were removed parallel to the orientation of the muscle fibers. Cores were sheared on an Instron® universal testing machine (Model 112). The shear force from each of the four cores was averaged together to give one shear value for each chop.

Data were analyzed utilizing the MIXED procedure in SAS (1999). The experiment was designed as a 2 x 2 factorial arrangement with chilling method: accelerated (AC) vs. conventional (CC) and enhancement: enhanced (EN) vs. non-enhanced (NE) as treatments. The model included the fixed effects of harvest day, chilling method, enhancement, and chilling*enhancement. Pig nested within harvest day as a random variable.

Results & Discussion

With the absence of many chill*enhancement interactions, the main effects for chill and for enhancement were evaluated. As indicated in Table 1, accelerated chilling caused an increase ($P \leq 0.05$) in the amount of purge loss after 10 d post-mortem. During the accelerated chilling process, loin sections became partially frozen while in the -27°C solution. Upon the removal of the loin sections, the freeze/thaw process may have caused this increase in the amount of purge present. With the use of accelerated chilling, there was a decrease ($P \leq 0.05$) in the L*a*b* values (darker, less red, less yellow). Subjective scores for color and striping increased ($P=0.049$ and $P=0.032$ respectively), while scores for marbling and firmness did not change ($P=0.054$ and $P>0.05$ respectively). Although significant differences ($P \leq 0.05$) were indicated by the subjective evaluations, accelerated chilling resulted in values that were only 0.2 units higher for both color and striping. The ability to visually detect these differences would be difficult. Accelerated chilling resulted in a lower ($P \leq 0.05$) percent cook loss and higher ($P \leq 0.05$) juiciness scores. There was no difference (P>0.05) for tenderness and off-flavor. Using accelerated chilling, loin sections underwent a very rapid decrease in the internal temperature of the meat. A rapid decrease in temperature, would help protect proteins from the detrimental low pH/high temperature phenomenon, and would result in the improved quality.

As presented in Table 1, the use of enhancement resulted in a difference (P≤0.05) for all traits measured except for subjective marbling scores (P>0.05). Percent purge at 10 d post-mortem and percent cook loss were lower (P≤0.05), objective color scores (L*a*b*) were lower (P≤0.05), and subjective scores for color, firmness, and striping were all higher (P≤0.05). While enhancement did result in increased striping scores, (1.5 vs. 1.1) these differences were minimal. As described by Gooding (2003) a score of 1.0 (1-5) indicated no striping and 2.0 indicated faint striping. With a score of 1.5, the striping in the enhanced sections would be difficult for an untrained person to observe. Trained taste panel evaluation indicated that enhanced pork was juicier, more tender, and had more off-flavor than non-enhanced pork (P≤0.05). The off-flavor that was detected by the trained taste panel may have been the result of some panelist detecting an excessive amount of salty taste that can be associated with enhanced pork. However, while the panel was able to detect more of an off-flavor in the enhanced pork, the mean value was 0.9 vs. 0.3 on a 15 point scale. Both of these values indicate minimal off-flavor. With the brine pH around 7.2, the use of enhancement was able to buffer up the pH in the enhanced loin sections (Table 2). With the increased pH, this would result in the binding of more water by the proteins found in the meat. This would lead to the improvement in percent purge and corresponding increase in juiciness. In addition, with more bound water, there would be less light reflectance at the surface of the loin, resulting in the darker color.

The addition of harvest day to the model was used to help control any day to day variation that would have been present. The exploration of the effect of harvest day indicated that during the second harvest day, the accelerated chilling sections were enhanced to a higher percentage than on the first day. This may have resulted in the significant interactions for 10 d pH (Table 2). In addition, the significant interaction for shear value may be explained by the aforementioned freezing of the accelerated chilling loin sections. As indicated in Table 2, the non-enhanced accelerated chilled section had the highest mean shear value (not significantly different (P>0.05) than the non-enhanced conventional chilled section), while the enhanced accelerated chilled section has the lowest mean shear value (not significantly different (P>0.05) than the enhanced conventional chilled section). Through the freezing that occurred in the accelerated chilling sections, the non-enhanced section may have undergone more freezing than the enhanced loin due to the absence of the brine solution. This extra freezing, may have damaged more of the proteolytic enzymes and hence less tenderization.

Conclusions

With the prevalence of pale, soft, and exudative pork still a problem in the pork industry, ways to prevent lower quality pork are advantageous. In this experiment, the use of enhancement was coupled with accelerated chilling in an effort to improve quality. The main effects of accelerated chilling and enhancement independently improved quality, but when coupled together, the improvement in quality was greater than the individual treatments alone. Hence, if a processor was able to couple these technologies together, they may be able to improve quality and increase consumer satisfaction.

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Tables and Figures

Table 1. Main Effects of Chilling Treatment and Enhancement Treatment

	Chill				Enhancement			
	AC	CC	SEM	*P*-value	EN	NE	SEM	*P*-value
10d Purge, %	3.42	2.74	0.33	0.0368	2.61	3.56	0.33	0.0046
Minolta L*	47.99	50.48	0.65	<.0001	47.02	51.45	0.65	<.0001
Minolta a*	7.80	8.45	0.19	0.0003	7.23	9.02	0.19	<.0001
Minolta b*	4.98	5.75	0.24	<.0001	4.35	6.39	0.24	<.0001
Color [a]	3.4	3.2	0.13	0.0491	3.6	3.1	0.13	0.0002
Marbling [b]	2.2	2.4	0.12	0.0544	2.4	2.3	0.12	0.4017

Firmness [c]	3.4	3.3	0.11	0.6846	3.5	3.2	0.11	0.0181
Striping [d]	1.4	1.2	0.08	0.032	1.5	1.1	0.08	0.0003
Cook Loss, %	19.70	22.49	0.94	0.0154	18.18	24.00	0.94	<.0001
Juiciness [e]	8.7	8.0	0.25	0.0125	9.4	7.2	0.25	<.0001
Tenderness [f]	9.2	8.7	0.33	0.0937	10.2	7.7	0.33	<.0001
Off-Flavor [g]	0.6	0.6	0.33	0.684	0.9	0.3	0.33	0.0002

Means are significantly different at $P \leq 0.05$

[a] NPPC, 1999 (1-6)

[b] NPPC, 1999 estimated % lipid

[c] NPPC, 1991(1-5)

[d] Gooding, 2003 (1=None 5=Severe)

[e] 0 = Extremely Dry, 15 = Extremely Juicy

[f] 0 = Extremely Tough, 15 = Extremely Tender

[g] 0 = None, 15 = Extremely Intense

Table 2. Chill * Enhancement Treatment Interactions

	Enhanced		Non-Enhanced			
	AC	CC	AC	CC	SEM	Interaction *P*-value
pH @ 10d	5.84[a]	5.73[b]	5.55[c]	5.54[c]	0.02	0.0032
WBS, kg	2.27[a]	2.54[a]	3.13[b]	2.93[b]	0.11	0.0277

[abc]Means within the same row with different superscripts are different at $P \leq 0.05$