

Effect of Enhancement of Pork and Beef on Postmortem Events



Dr. John Killefer

Associate Professor of Muscle Biology

Department of Animal Science

University of Illinois

Overview

- **Animal Metabolism**

- Ante-Mortem
- Post-Mortem

- **Enhancement Process**

- Why Enhance
- Advantages and Disadvantages
- Brine Components

- **Early Post-Mortem Manipulation**

- Enhancement
- Accelerated Chilling

- **Current U of I research**

- **Conclusions and Recommendation**

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Animal Metabolism

- **Ante-Mortem Metabolism**

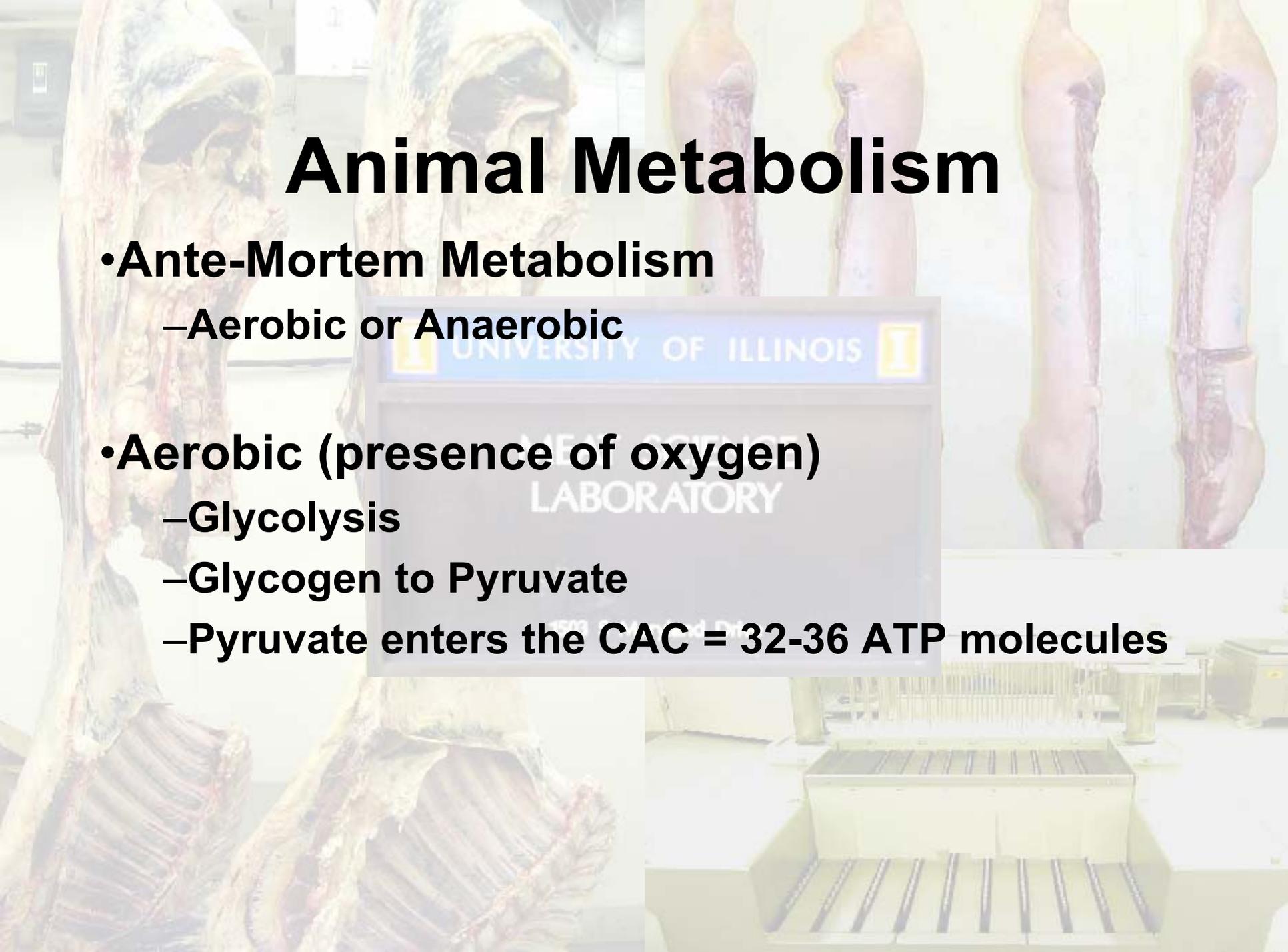
- Aerobic or Anaerobic

- **Aerobic (presence of oxygen)**

- Glycolysis

- Glycogen to Pyruvate

- Pyruvate enters the CAC = 32-36 ATP molecules



Animal Metabolism

- **Anaerobic (lack of oxygen)**
 - **Glycolysis**
 - **Glycogen to Pyruvate**
 - **Pyruvate does not enter the CAC, instead converted to Lactic Acid**
 - **LA removed from tissue by circulatory system**
 - **Transported to liver**
 - **Through gluconeogenesis, LA metabolized into glucose via the Cori Cycle**

Animal Metabolism

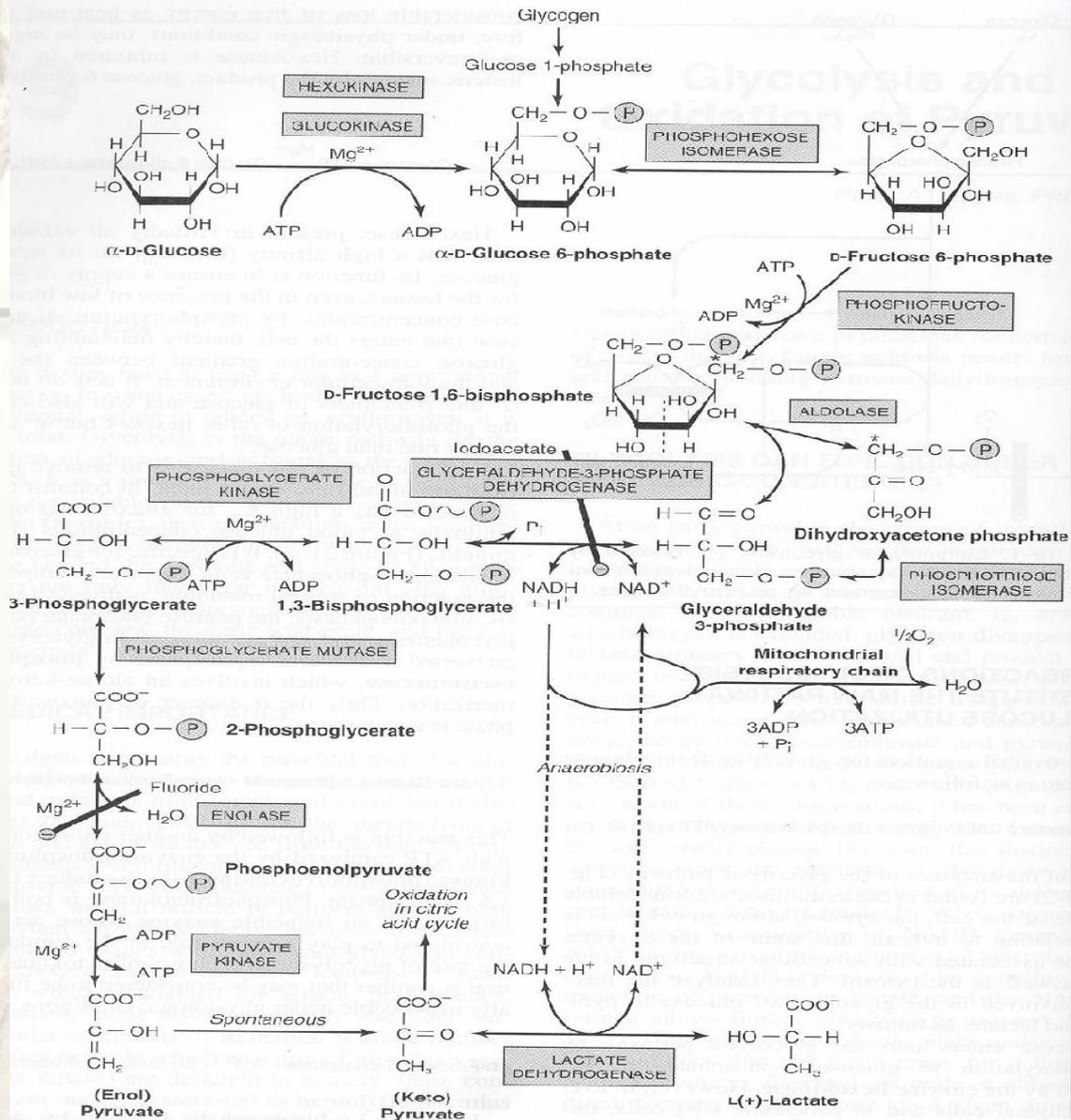
• Post-Mortem Metabolism

- Glycolysis
- Glycogen to Pyruvate
- No Oxygen
- Pyruvate to LA
- No Circulatory System Present
- LA and metabolic heat cannot be removed
- ↑ LA causes ↓ in tissue pH (from 7.0 to ≈ 5.5)
- Tissue temperature increases ($\approx 5^\circ$)
- Rate of pH decline and temperature play a major role in determining meat quality

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Animal Metabolism



Enhancement

Why Enhance

• Advantages

- Change of flavor profile
- ↑ Juiciness
- ↑ Tenderness
- Improved Color
- Improved Shelf Life
- Improved Cooking attributes

• Disadvantages

- Change of flavor profile
- Increased Production Cost
- Visual Problems
 - Striping
 - Surface exudate

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Enhancement

- **Brine Components for Fresh Product**
 - **Salt (typically .1 to .4% in final product)**
 - Improves water holding capacity
 - **Phosphates (up to .5% in final product)**
 - Improves water holding capacity
 - **Anti-Oxidants/Anti-Microbials (e.g. Lactates)**
 - Improve shelf stability of the product
 - **Flavorings**
 - Change the flavor profile of the product

Early Post-Mortem Manipulation

- Enhancement provides many positives
- Under common practice, enhancement of product is used once the quality of the product has already been determined
- Limited improvement of poor quality product

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Early Post-Mortem Manipulation

- However, if the product is manipulated before the ultimate quality is determined, some unique opportunities may exist
 - Early post-mortem enhancement
 - Accelerated chilling of product

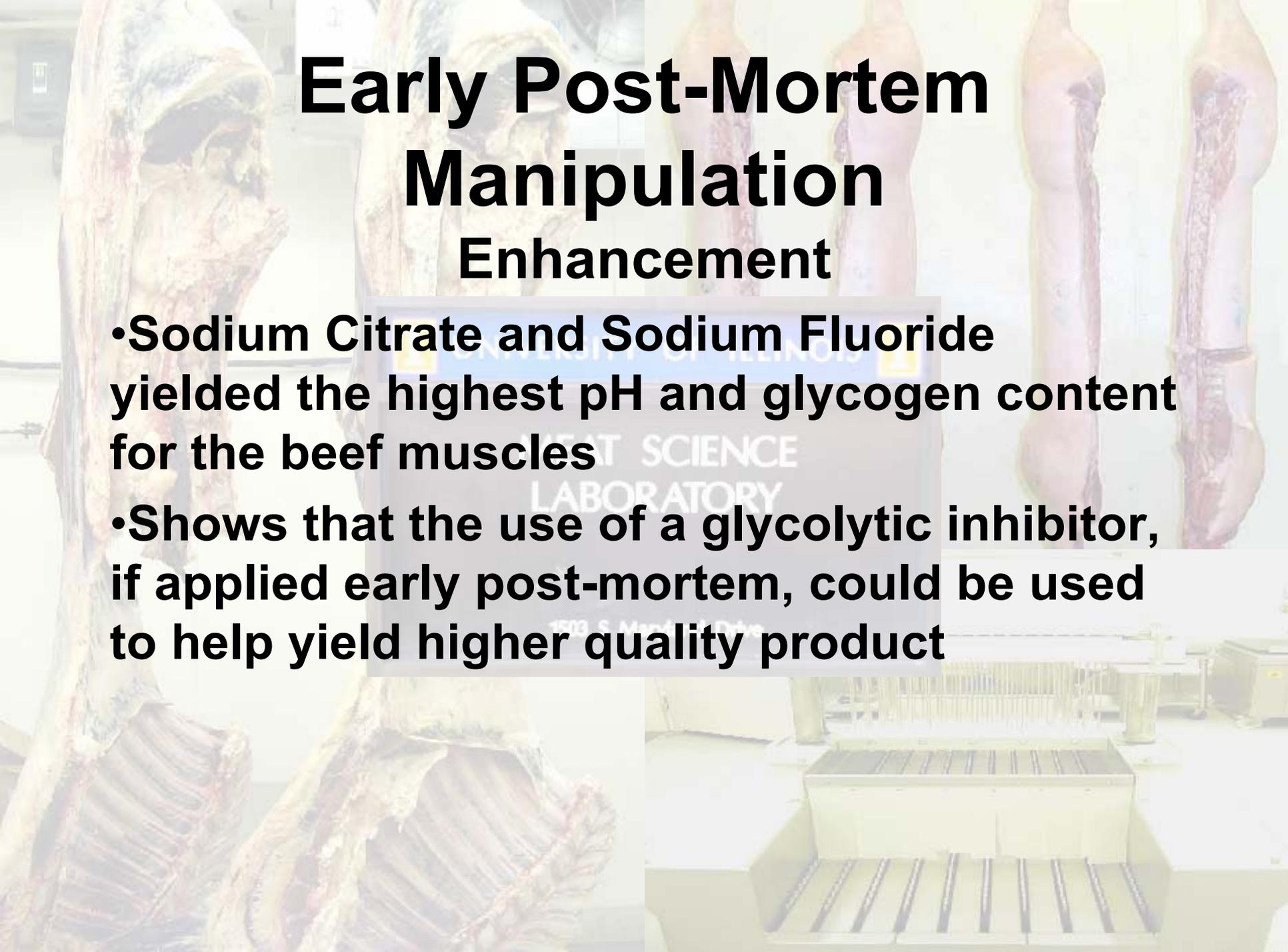
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Early Post-Mortem Manipulation Enhancement

- Early post-mortem enhancement with glycolytic inhibitors has been explored
- Jerez et al., 2003 used Sodium Citrate, Sodium Fluoride, Sodium Acetate, or Calcium Chloride in early post-mortem beef muscles
- Hot-boned muscles at 1h post-mortem and injected and tumbled with a 10% by wt solution

Early Post-Mortem Manipulation Enhancement

- Sodium Citrate and Sodium Fluoride yielded the highest pH and glycogen content for the beef muscles
- Shows that the use of a glycolytic inhibitor, if applied early post-mortem, could be used to help yield higher quality product



Early Post-Mortem Manipulation

Enhancement

- Use of salt and phosphate early post-mortem
- Murphy and Zerby, 2004 in lamb carcasses
- Used different combinations of salt, phosphate, and dextrose
- Results indicated that some of the combinations of the different ingredients yielded higher ultimate pH, decreased cook loss, and increased tenderness

Early Post-Mortem Manipulation

Accelerated Chilling

- Accelerated chilling of the product allows for the possibility of improved product quality
- Honikel and Kim, 1986 showed that if the pH was less than 5.8 and the internal temperature was greater than 38 C, this would lead to protein denaturation
- Therefore, the accelerated chilling of the product may be able to help improve quality, by slowing the metabolic activity of the carcass

Early Post-Mortem Manipulation

Authors	Test	Results
Ohene et. al., 2002	Intact Pork Sides, three chill treatment	Minimal improvements in quality from AC compared to CC
Ohene et. al., 2003	Intact Pork Sides, Halothane Carriers, two treatments	AC improved quality over the CC, in the LD but not the ham
Long and Tarrant, 1990	Pigs harvested in different seasons and treated to different cooling rates	Rapid Chilling reduced carcass temp and pH decline, decreased drip loss in ham
Crenwelge, et. al., 1984	Pigs harvested, sides ES, three chilling methods	The more rapid chilling increased muscle color for the ham, optimal temp reached faster in the rapid chilling methods
Weakley, et. al., 1986	Hot-bone loin, and placed in different cooling treatments	Rapid chilling caused darker muscle compared to normal chill
Seyfert, et. al., 2004	Beef Rounds, hot-boned knuckle, enhanced, MAP packaged	Hot-boning allowed for more rapid chilling, which resulted in darker color beef
King, et. al., 2003	Beef muscles were hot-boned and rapidly chilled, looked at different cooking methods also	The rapidly chilled sections had a faster temperature decline and numerically different rate of pH decline, resulted in cold shortening
Conclusions	Accelerated chilling can slow the rate of pH decline and increase the rate of chilling. This can cause an improvement in protein functionality leading to improved water holding capacity and improved color	

Early Post-Mortem Manipulation

- While some of the results may vary, it is possible to improve meat quality with accelerated chilling
- Results show that early post-mortem enhancement can improve meat quality
- The combination of early post-mortem enhancement and accelerated chilling has not been extensively explored

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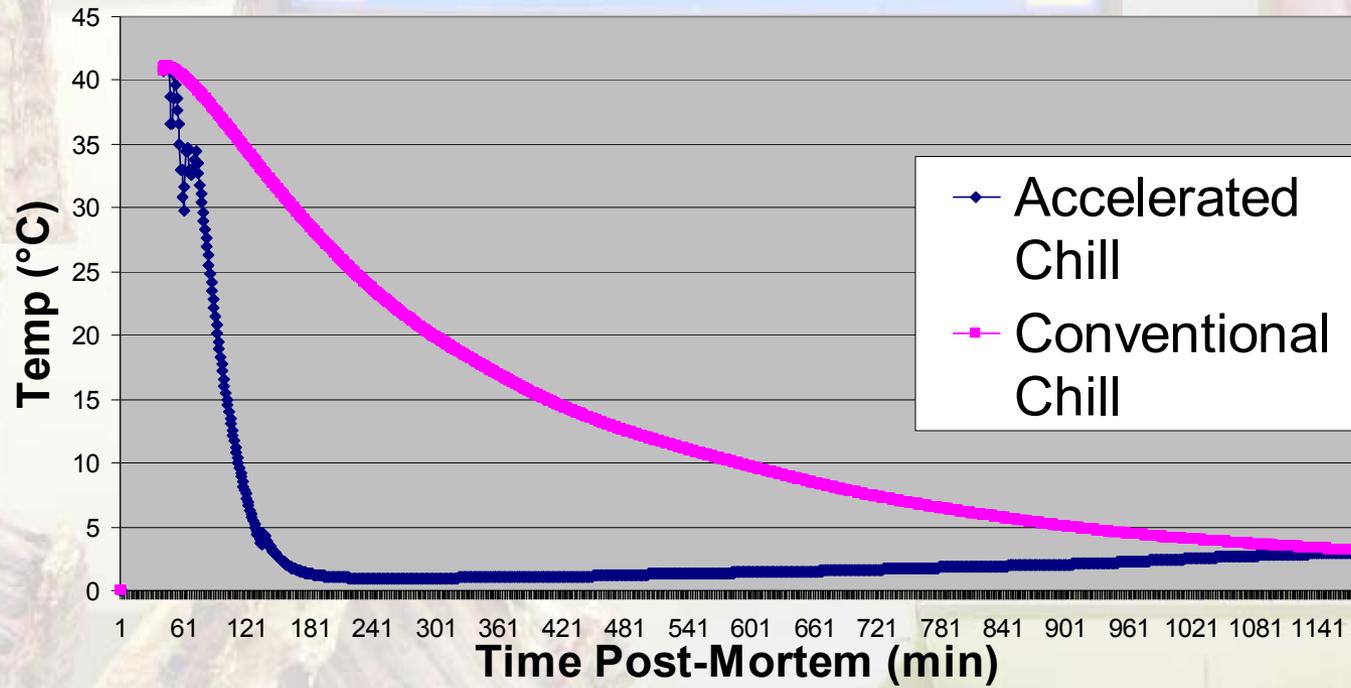
Accelerated Chilling

- **Conventional Chill vs. Accelerated Chill**
- **10 pigs (2 harvest days, 5 pigs per day)**
 - **Left Side Control**
 - 24 hour at 4°C then ribbed
 - **Right Side Test**
 - Hot-Boned at 1hour, Chilled 1hour @ -27°C, stored 4°C for 23 hour



U of I Research Accelerated Chilling

Temperature Decline
Accelerated vs Conventional Chill



Graph from 10 loins per treatment

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Accelerated Chilling

	Control	Chilled	SE	Prob> T
30 min	6.17	6.16	0.03	0.5579
1 h pH	5.98	5.83	0.12	0.2581
2 h pH	5.63	5.71	0.12	0.5108
3 h pH	5.43	5.60	0.06	0.0142
5 h pH	5.45	5.64	0.07	0.0229
6 h pH	5.48	5.61	0.07	0.0766
8 h pH	5.49	5.59	0.04	0.0547
20 h pH	5.49	5.53	0.03	0.1479
Ult pH	5.48	5.49	0.03	0.5397
Subjective Color	2.40	3.00	0.22	0.0239
Hunter L*	56.56	53.70	1.01	0.0193
% Drip Loss	5.20	4.35	0.52	0.1405
6-7 Day % Cook Loss	26.91	22.29	1.72	0.0247
6-7 Day Shears	5.50	5.22	0.40	0.4992

Significance $p < .05$

Trending $p < .10$

U of I Research Accelerated Chilling

- Higher pH at 3, 5, 6, and 8 hour post-mortem, coupled with reduced temperature resulted in improved quality

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Enhancement and Accelerated Chill

- **Enhancement in combination with accelerated chilling**

- **16 pigs total (2 harvest days, 8 pigs per day)**

- **Treatments:**

- **Conventional Chill Only (CC Only)**

- **Conventional Chill with Enhancement (CCEN)**

- **Accelerated Chill Only (AC Only)**

- **Accelerated Chill with Enhancement (ACEN)**

- **Brine Solution**

- **.4% Salt, .4% Phos, 2.5% K-Lactate in final product**

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Enhancement and Accelerated Chill

Pig 1

Left

Right

CC Only
CC EN

AC Only
AC EN

Pig 2

Left

Right

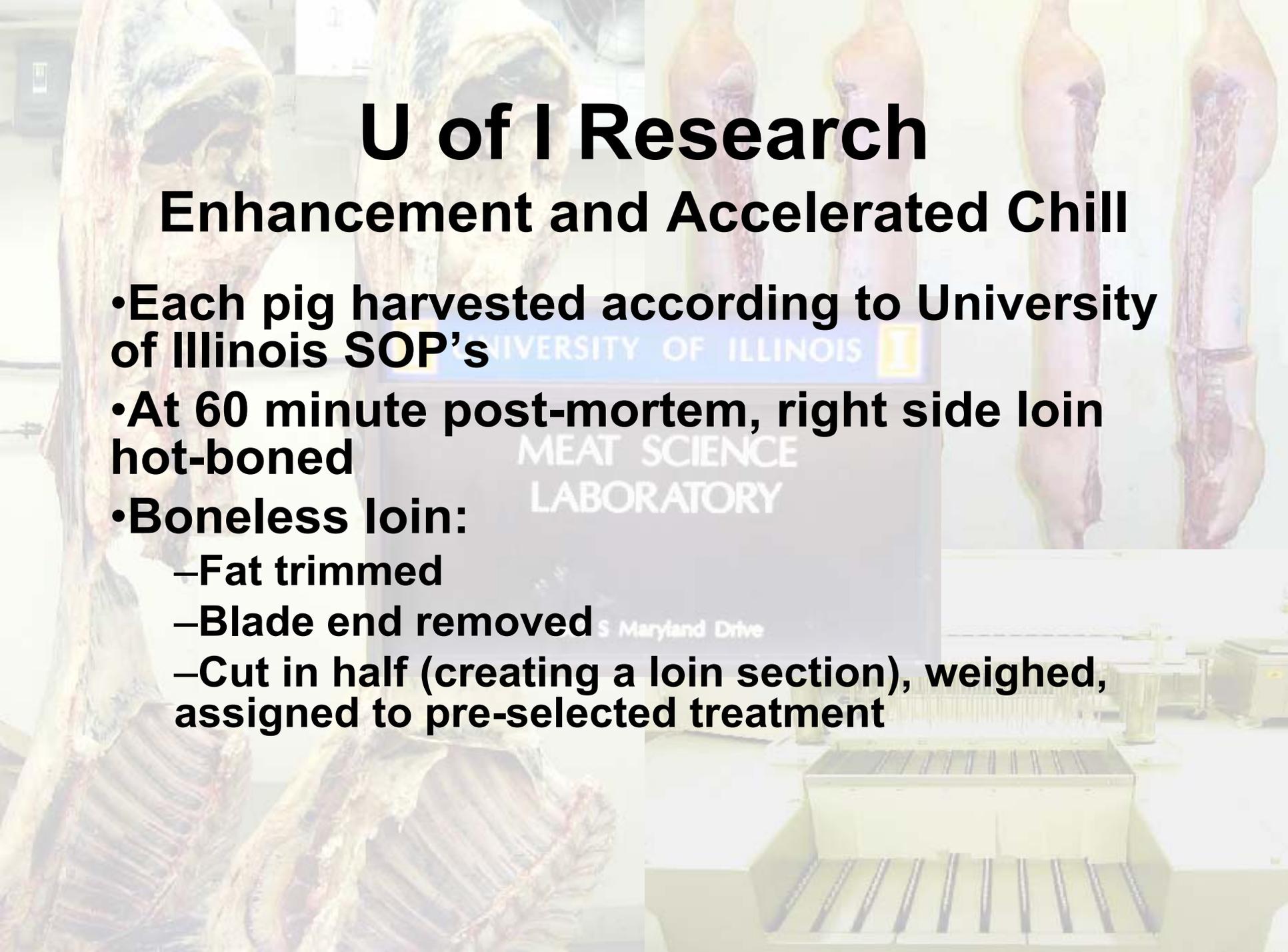
CC EN
CC Only

AC EN
AC Only

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Enhancement and Accelerated Chill

- Each pig harvested according to University of Illinois SOP's
- At 60 minute post-mortem, right side loin hot-boned
- Boneless loin:
 - Fat trimmed
 - Blade end removed
 - Cut in half (creating a loin section), weighed, assigned to pre-selected treatment



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Enhancement and Accelerated Chill

- **Treatments:**

- AC Only

- AC EN (Enhanced First)

- **Placed -27°C PG solution 1 hour**

- **Removed, stored at 4°C until 10 day post-mortem**

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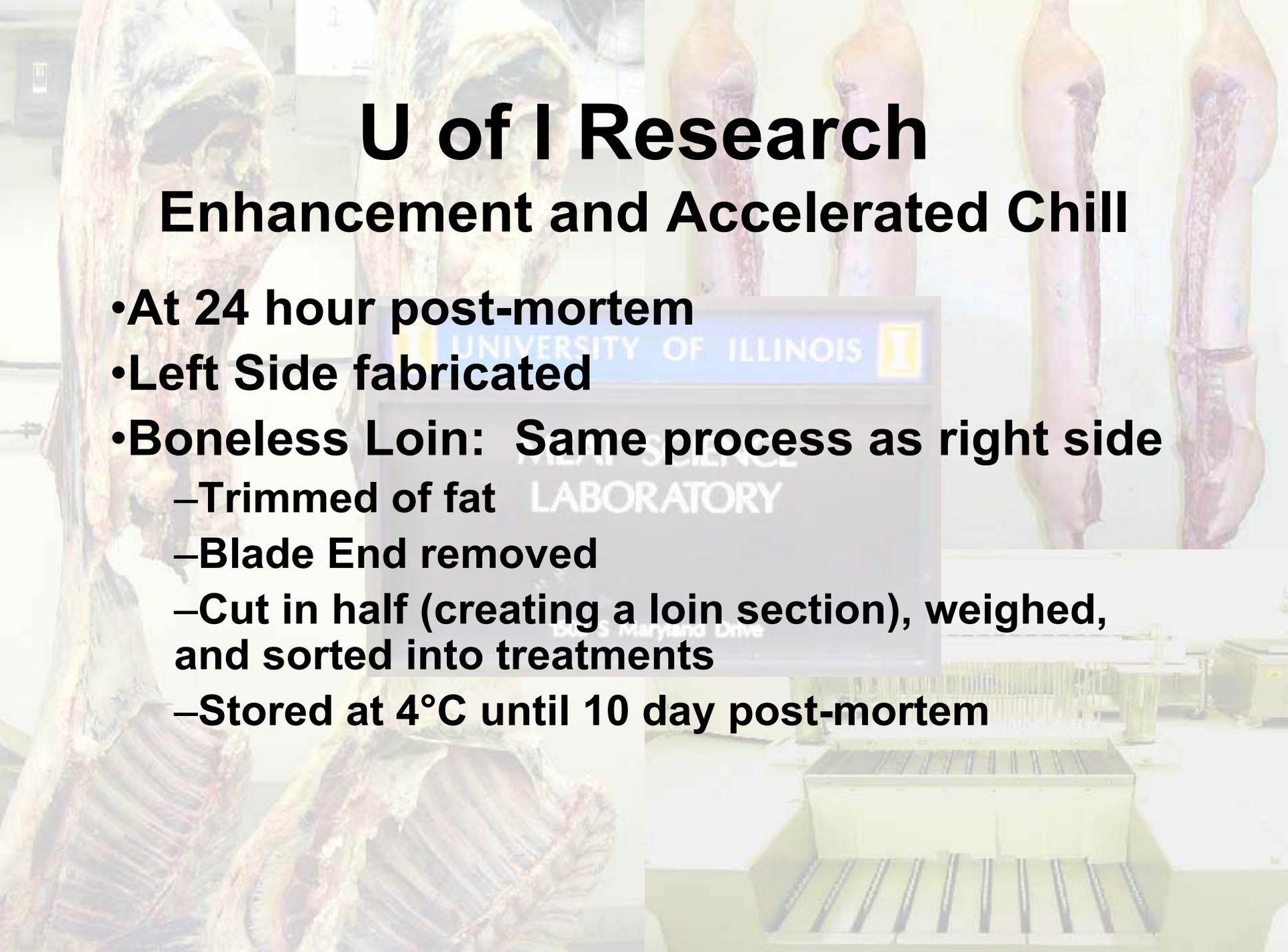
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Enhancement and Accelerated Chill

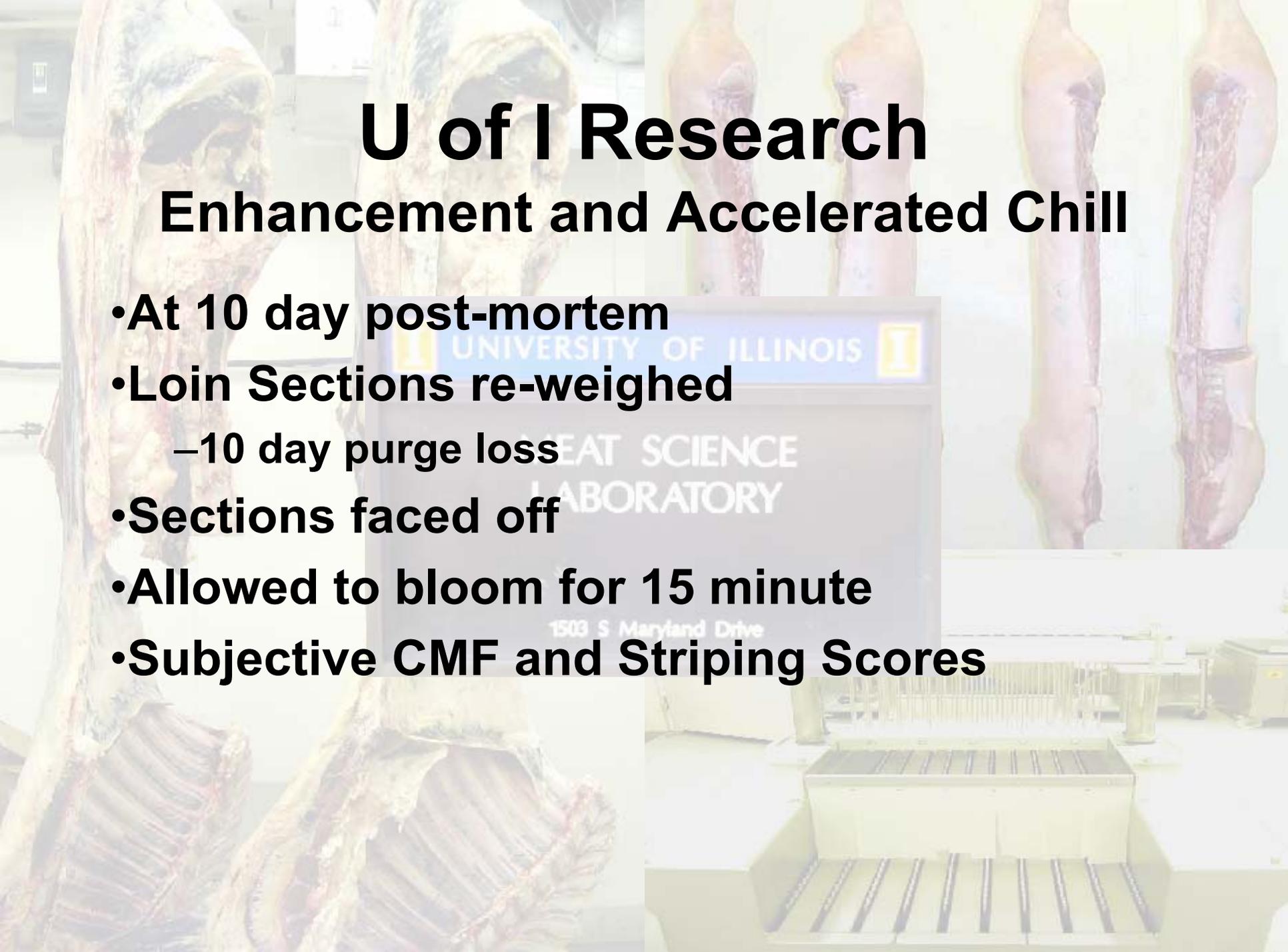
- **At 24 hour post-mortem**
- **Left Side fabricated**
- **Boneless Loin: Same process as right side**
 - Trimmed of fat
 - Blade End removed
 - Cut in half (creating a loin section), weighed, and sorted into treatments
 - Stored at 4°C until 10 day post-mortem



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Enhancement and Accelerated Chill

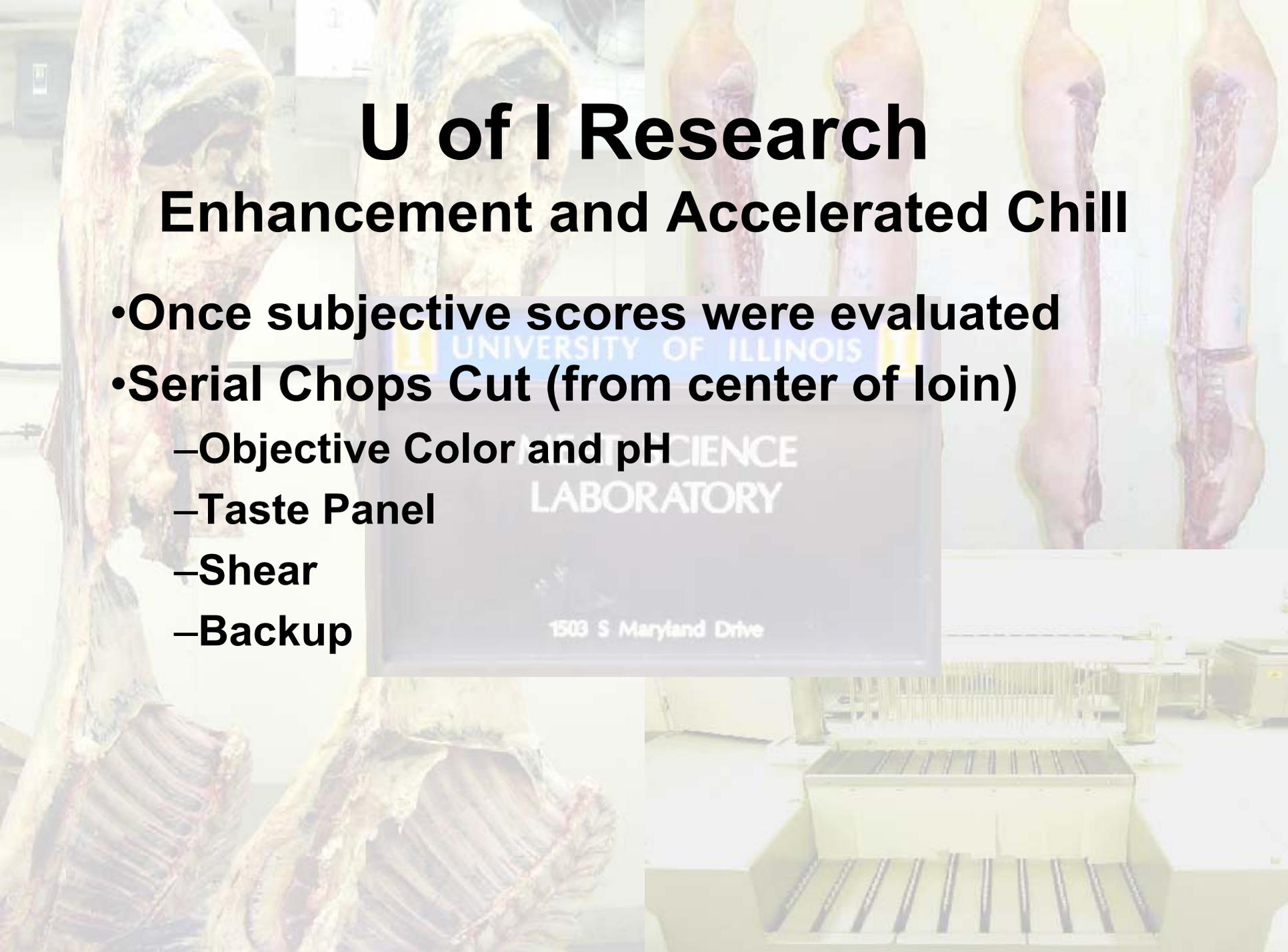
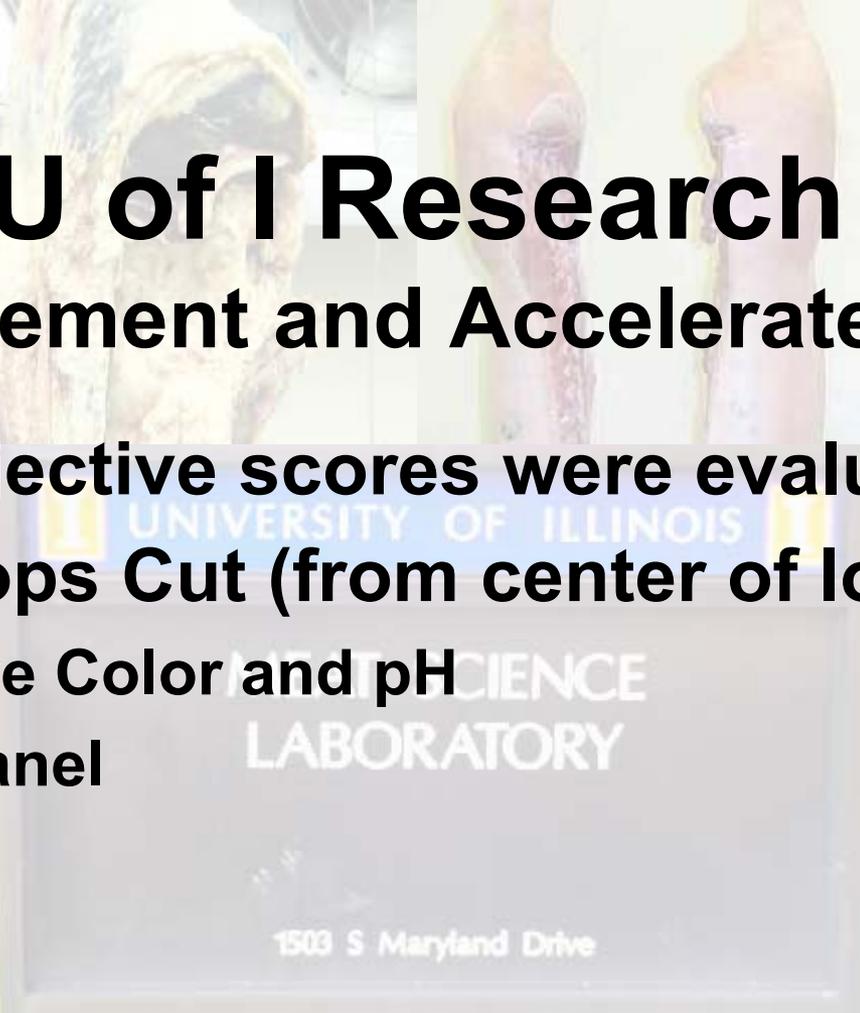
- At 10 day post-mortem
- Loin Sections re-weighed
 - 10 day purge loss
- Sections faced off
- Allowed to bloom for 15 minute
- Subjective CMF and Striping Scores



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Enhancement and Accelerated Chill

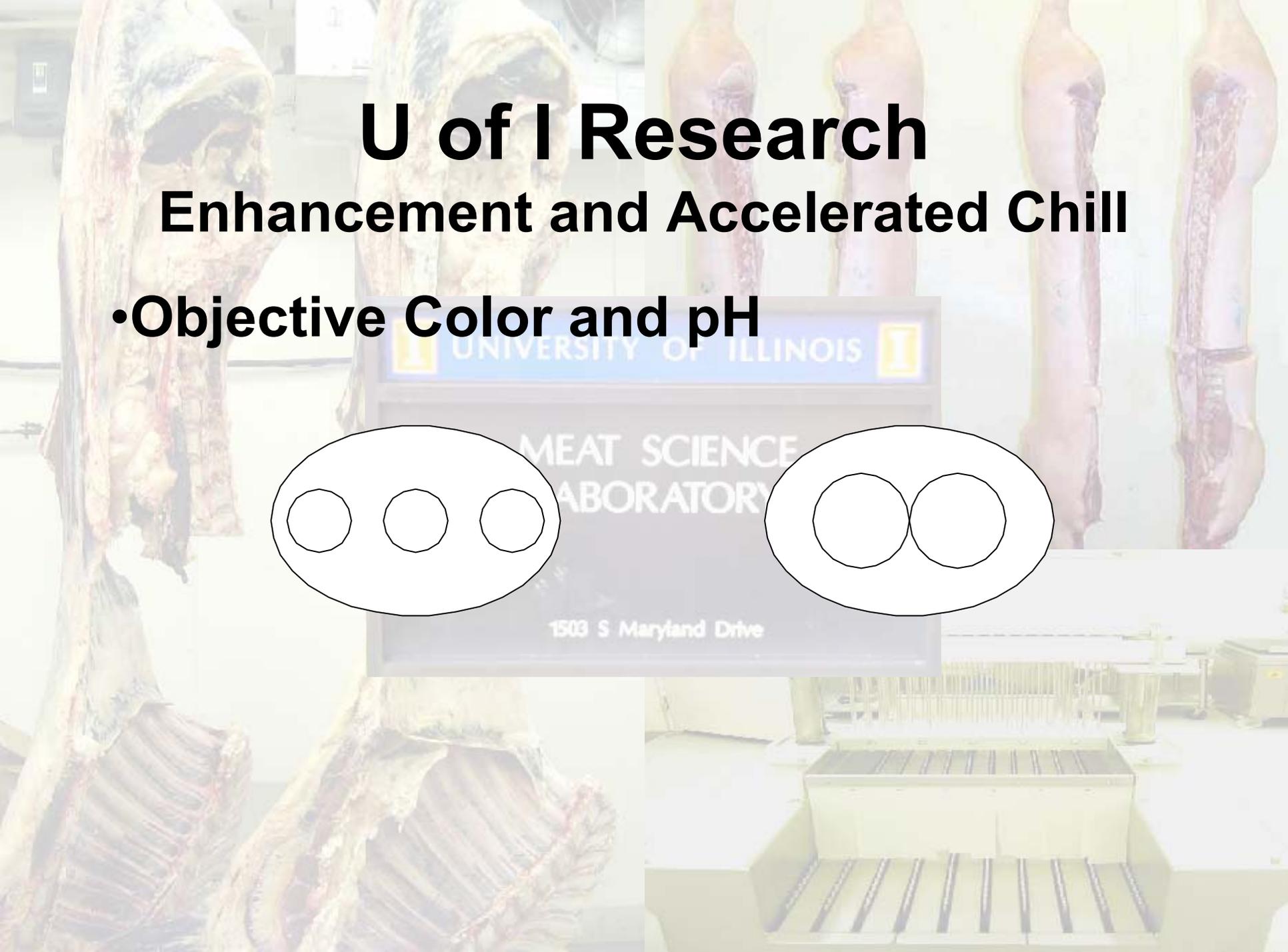
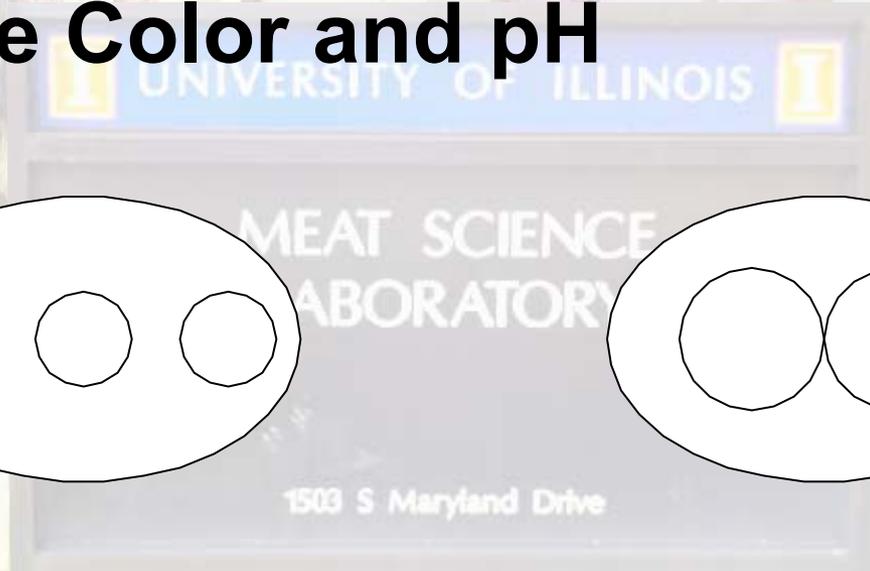
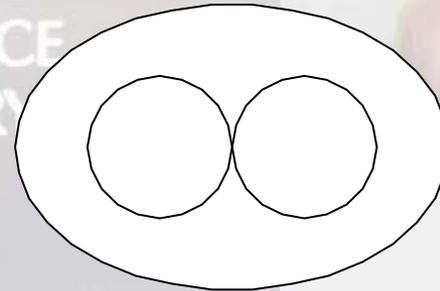
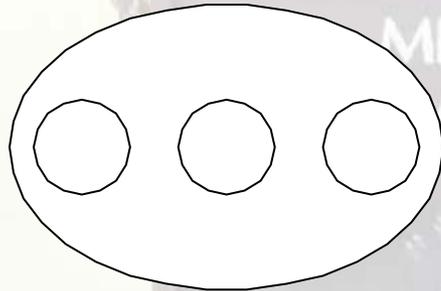
- Once subjective scores were evaluated
- Serial Chops Cut (from center of loin)
 - Objective Color and pH
 - Taste Panel
 - Shear
 - Backup



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Enhancement and Accelerated Chill

- Objective Color and pH



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Enhancement and Accelerated Chill

Water Holding Capacity

	AC	CC	p-value	EN	Non-EN	p-value	Interaction
% 10 Day Purge	3.4	2.7	0.0479	2.6	3.6	0.0093	0.9804
% Cook Loss	19.7	22.5	0.0079	18.2	24.0	0.0009	0.7863

Significance is determined at $p < .05$

*****Scheffe adjustment

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Enhancement and Accelerated Chill

Subjective and Objective Scores

	AC	CC	p-value	EN	Non-EN	p-value	Interaction
Subjective Color	3.4	3.2	0.041	3.6	3.0	0.0002	0.1639
Subjective Firmness	3.4	3.3	0.576	3.6	3.1	0.0114	1.0000

Significance is determined at $p < .05$

*****Scheffe adjustment

	AC	CC	p-value	EN	Non-EN	p-value	Interaction
Minolta L*	47.99	50.48	0.0007	47.02	51.45	<.0001	0.3092

Hunter L	52.20	54.38	0.0018	51.54	55.04	0.0002	0.0668
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Significance is determined at $p < .05$

*****Scheffe adjustment

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Enhancement and Accelerated Chill

- **Results indicate that accelerated chill improves pork quality over conventional chill**
 - **Improved Color and Water Holding Capacity**
- **Results also indicate that pork quality was increased by enhancement**

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Enhancement and Accelerated Chill

- The combination of accelerated chilling and enhancement resulted in higher quality pork compared to conventional methods

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Glycolytic Inhibitors

- The effects of a glycolytic inhibitor in early post-mortem pork
- N=20
- Test to determine the use of a glycolytic inhibitor (sodium citrate) in early post-mortem muscle

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Glycolytic Inhibitors

- At approximately 1 h post-mortem, the loin was removed from both sides of the carcass, cut in half and assigned to the control treatment (salt and phos) or the test (salt, phos, NaC)
- Each section was vacuum packaged at 24h post-mortem and stored until 7 d post-mortem

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Glycolytic Inhibitors

- At 7 d post-mortem evaluations were made on the loin sections.
- Chops cut from each loin section
 - GP
 - Shear and cook loss
 - MAP package
- At 14 d post-package, the MAP packaged chops were objectively evaluated for color

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Glycolytic Inhibitors

	Control	Test	Pr > t
Color	3.2	3.7	0.0104
Firmness	3.4	3.8	0.0611
L*	49.80	46.98	<.0001
Final pH	5.78	5.87	0.0012
% Cook Loss	25.48	18.00	0.0014
Shear Value	3.14	2.74	0.0374
14 Day MAP package L*	52.60	49.11	<.0001

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Glycolytic Inhibitors

- At 7 d post-mortem the test sections had a higher pH
- Sections that had been enhanced with NaC, had improved color scores (both objective and subjective), less cook loss, and improved shear force values
- At 14 d post-package (21 d p-m), the test chops were darker and more red (lower L^* and higher a^* values) than the controls

PORK QUALITY STANDARDS

pork The Other White Meat®

Quality of fresh pork varies greatly. The quality levels shown below will appear differently to consumers, taste differently when cooked, and perform differently when converted to processed products. High quality pork has greater monetary value than low quality pork. Quality can be evaluated by simple visual appraisal, or it can be determined more accurately by scientific tests. This chart may be used to help identify variations in pork quality. Color and Marbling Standards cards are also available.

COLOR - TEXTURE - EXUDATION



PSE Pale pinkish gray, very Soft and Exudative. Undesirable appearance and shrinks excessively.



RFN Reddish pink, Firm and Non-exudative. "IDEAL". Desirable color, firmness and water-holding capacity.



DFD Dark purplish red, very Firm and Dry. Firm and sticky surface, high water-holding capacity

COLOR STANDARDS



1.0

Pale pinkish gray to white

Minolta L* Value¹ 61



2.0

Grayish pink

55



3.0

Reddish pink

49



4.0

Dark reddish pink

43



5.0

Purplish red

37



6.0

Dark purplish red

31

MARBLING STANDARDS²



1.0



2.0



3.0



4.0



5.0



6.0



10.0

Color and marbling scores are as described in "Composition & Quality Assessment Procedures", 1993, NPPC.
¹ Minolta L* values use D65 daylight light source.
² Marbling scores correspond to intramuscular lipid content.

For more information contact:
 National Pork Producers Council

P.O. Box 11280
 One Mohr, Iowa 50308 USA
 (515) 281-2422
 www.nppc.org



Conclusions and Recommendations

- The combination of early post-mortem enhancement and accelerated chilling has the potential to improve quality (patent pending)
- However, while this can be done at a research level, implementation at the plant level may require alterations in operations
- Implementation at the plant level may be advantageous for consistent production of higher quality product

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