Beef Tenderness: Determination, Regulation and Prediction

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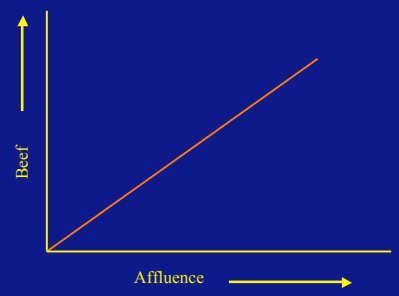
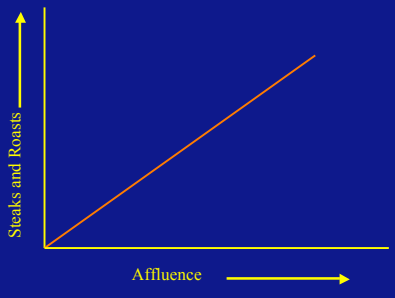
Presentation Outline

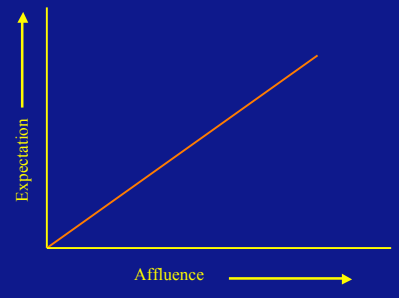
- What do consumer expect?
- How to meet consumer expectations?

World-wide Meat Consumption

- Notwithstanding the recent economic down turn, the world GDP and wealth had been increasing resulting in a significant increase in the number of people in the middle class and affluence in general.
- "one billion people joined the middle class in 2007. That is a big market for protein products, and who can take care of that need better that U.S. beef producers?" Andy Groseta, 2008 NCBA Pats President







Meeting Consumer Expectations

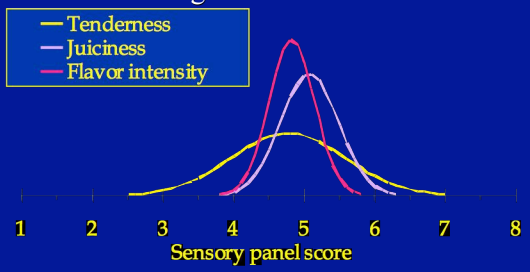
Consumer Expectations

- Eating satisfaction
  - Tenderness
  - Juiciness
  - Flavor
- Ease of preparation

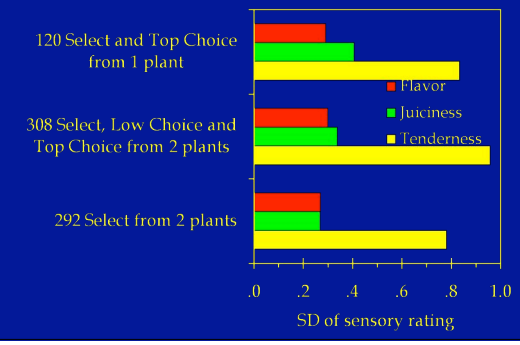
What to predict?

- Tenderness
- Flavor
- Juiciness

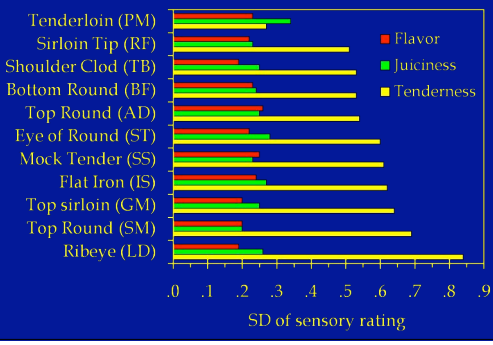
Variation in sensory traits of longissimus steaks



SD of trained sensory panel ratings of longissimus steaks



Effect of muscle on SD of trained sensory panel ratings



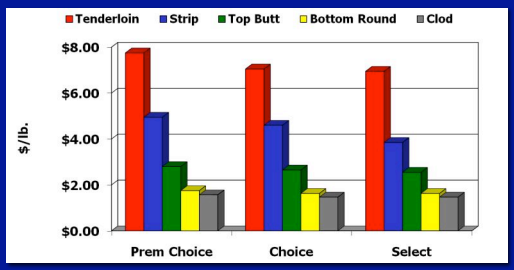
Also

Consumers consider tenderness to be the most important factor that affects their eating satisfaction and numerous consumer surveys have clearly demonstrated that consumers are willing to pay extra if we guarantee tenderness

Consumers will pay a premium

Tenderness vs Price

Value of Tenderness: Cut versus Grade?



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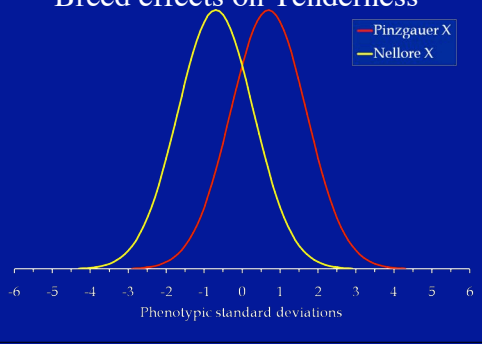
What to predict

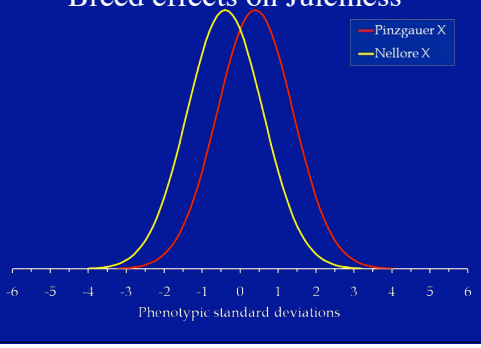
- ✓Tenderness
- Flavor
- Juiciness

Effect of Breeds on Tenderness

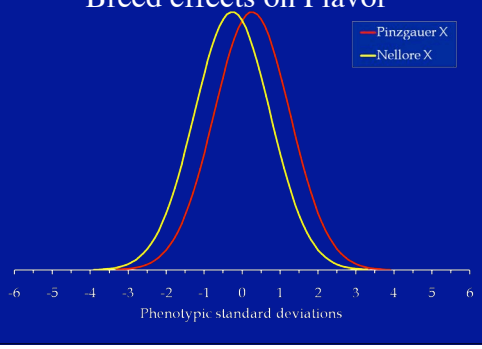
Breed effects on Tenderness



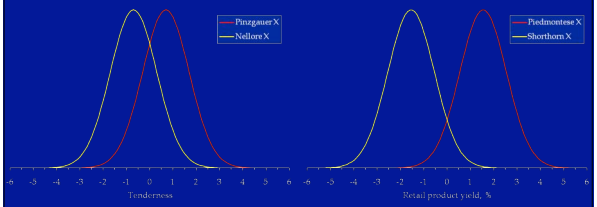
Breed effects on Juiciness



Breed effects on Flavor



Breed effects on Tenderness and Retail Product Yield



GPE Cycle VI (1997-1998)
Effect of Sire Breed on Ribeye
W-B shear force at 14 d

Breed	Mean	Range	% > 5 kg
Wagyu	3.7	2.3 to 5.5	3
Hereford	3.8	2.6 to 6.1	6
Angus	4.0	2.6 to 5.9	4
Norwegian Red/ Swedish Red & White	4.1	3.1 to 6.0	10
Friesian	4.2	3.0 to 7.5	11

GPE Cycle VII (1999-2000)
Effect of Sire Breed on Ribeye
W-B shear force at 14 d

Breed	Mean	Range	% > 5 kg
Hereford	4.1[b]	2.7 to 7.7	6
Angus	4.0[b]	2.7 to 6.1	11
Red Angus	4.2[b]	2.8 to 6.6	11
Simmental	4.3[ab]	2.6 to 6.5	23
Gelbvieh	4.5[a]	2.9 to 6.7	30
Limousin	4.2[b]	2.9 to 6.5	21
Charolais	4.4[a]	2.4 to 7.0	21

Therefore,

To meet consumer expectation, the variation in meat tenderness must be controlled/managed.

Biological Basis of Beef Tenderness

How do we measure these traits?

How do we measure these traits?

Tenderness -- Warner-Bratzler Shear force

-- Slice Shear Force

What is shear force?

What is shear force?

It is an objective method to measure meat tenderness.

Shear Force Determination

Shear Force Determination

Use of slice shear force for routine tenderness measurement

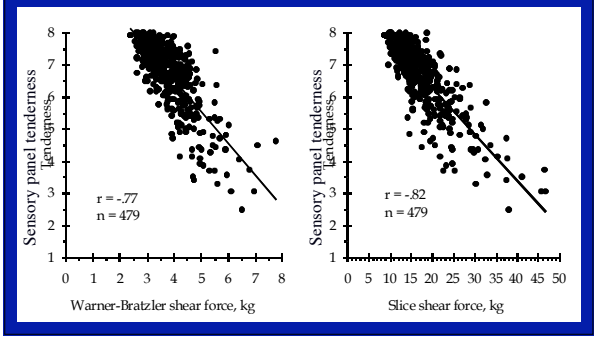
- Warner-Bratzler shear force is:
  - laborious and requires a high degree of skill.
  - not conducive to high-throughput.
- We developed a simple and just as accurate system called Slice Shear Force Value g (SSF).

Broiling

Slicing

Slice Shear Force Determination

Correlation of WBSF and SSF with SPT



How do we measure these traits?

1. Shear force – Objective measure of tenderness
2. Trained Sensory Panel – Objective measure of tenderness, juiciness and flavor
3. Consumer panels – Eating satisfaction (measure of desirability)

Sources of variation in meat tenderness

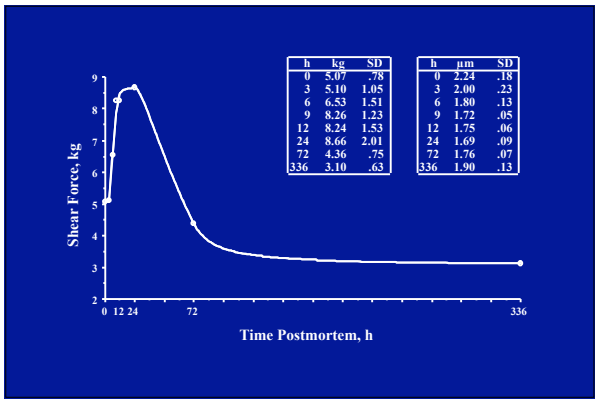
Tender; WBS = 2.8 kg

Tough; WBS = 9.0 kg

Sources of variation in meat tenderness

1. Exists at slaughter
2. Created during processing/Harvest
3. Both

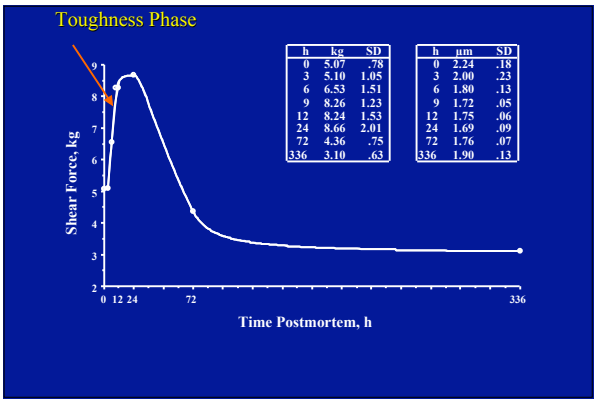
Biological basis of meat tenderness (Only Longissimus)



h	kg	SD
0	5.07	.78
3	5.10	1.05
6	6.53	1.51
9	8.26	1.23
12	8.24	1.53
24	8.66	2.01
72	4.36	.75
336	3.10	.63

h	µm	SD
0	2.24	.18
3	2.00	.23
6	1.80	.13
9	1.72	.05
12	1.75	.06
24	1.69	.09
72	1.76	.07
336	1.90	.13

Toughness Phase



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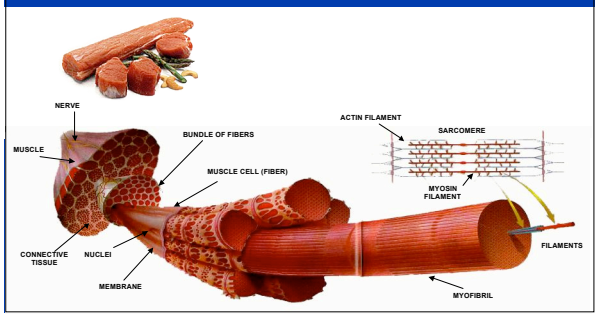
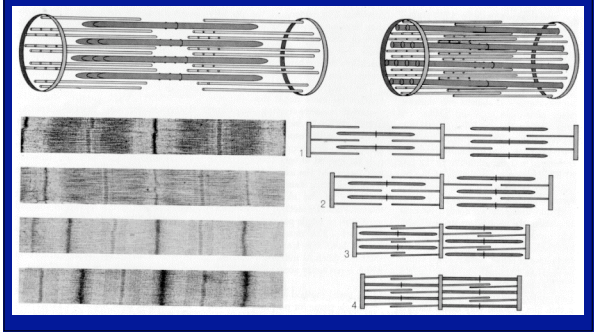
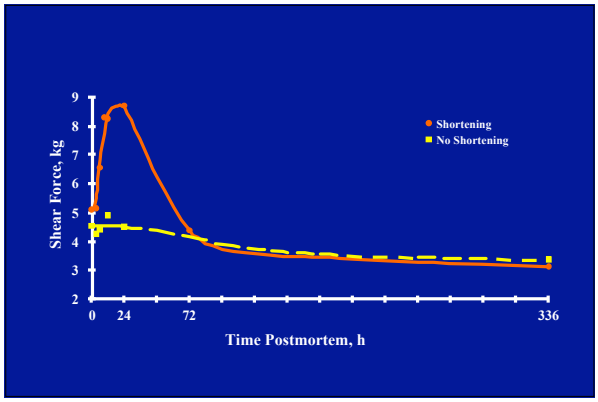
72	1.76	.07
336	1.90	.13

Muscle (meat) ultrastructure

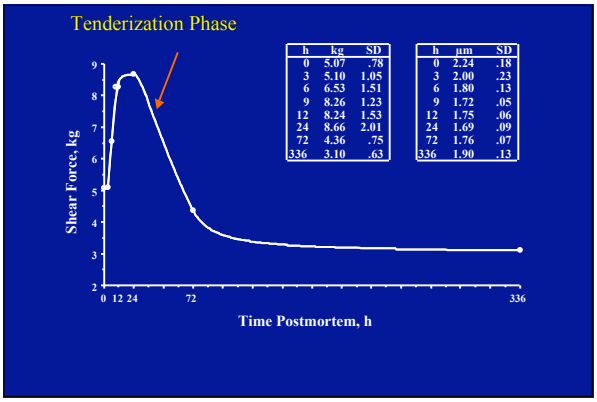


Rigor mortis





Tenderization Phase



h	kg	SD
0	5.07	.78
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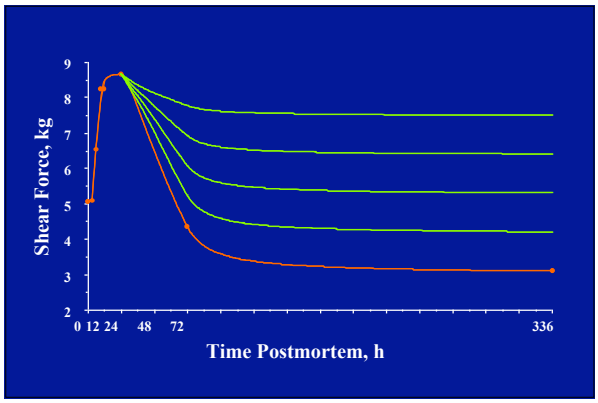
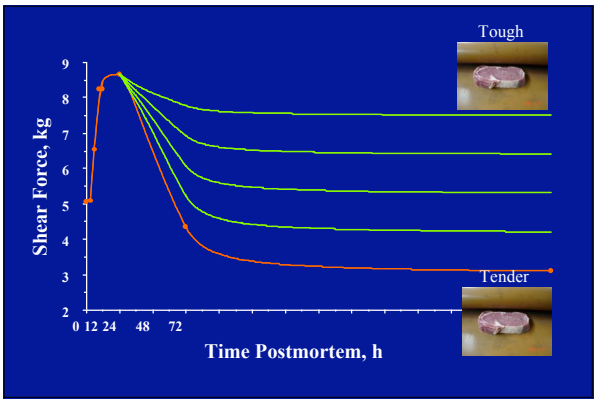
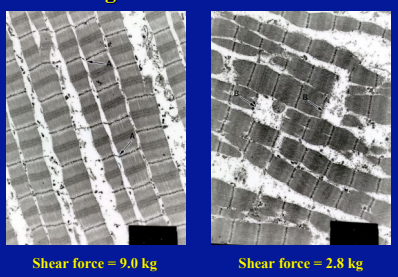
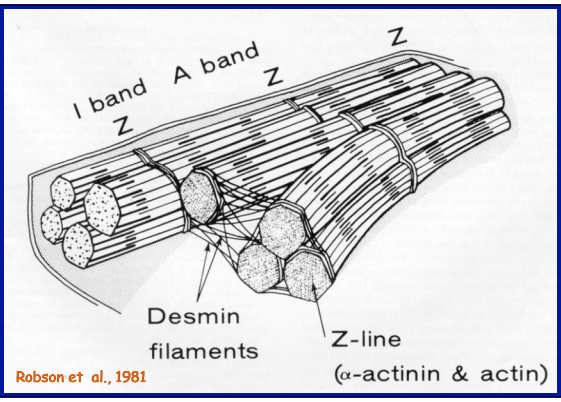




Mechanism of Postmortem Meat Tenderization





Degradation of key muscle proteins is responsible for postmortem meat tenderization

The function of these proteins is to maintain structural integrity of myofibrils

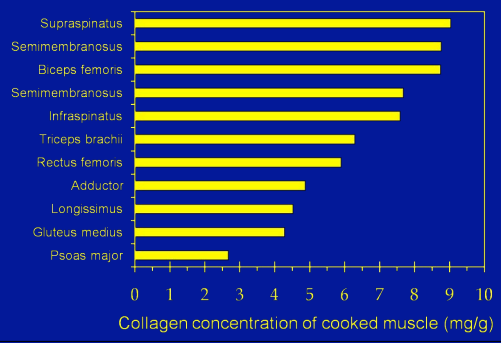
Differences in the rate and extent of degradation of these proteins are responsible for differences in the rate and extent of postmortem meat tenderization

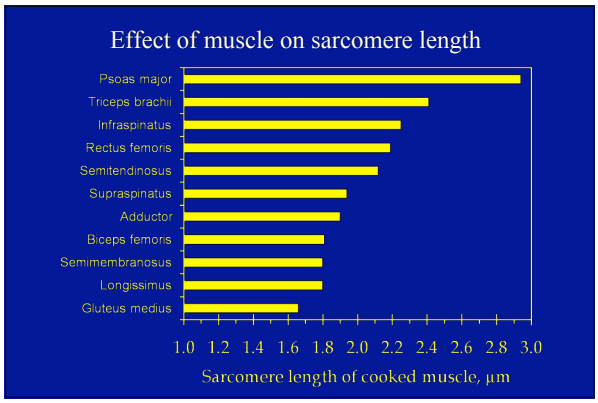
The Calpain Proteolytic system

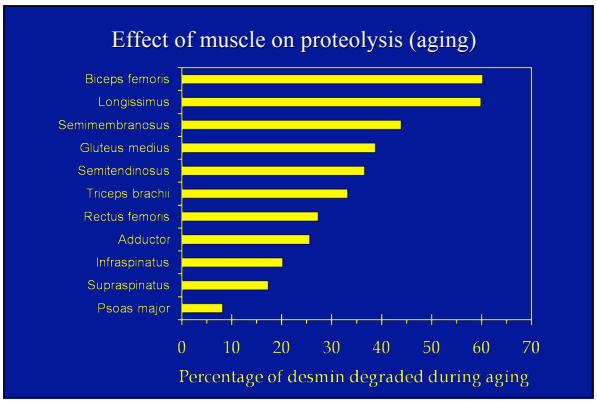
Meat Tenderness Determinants

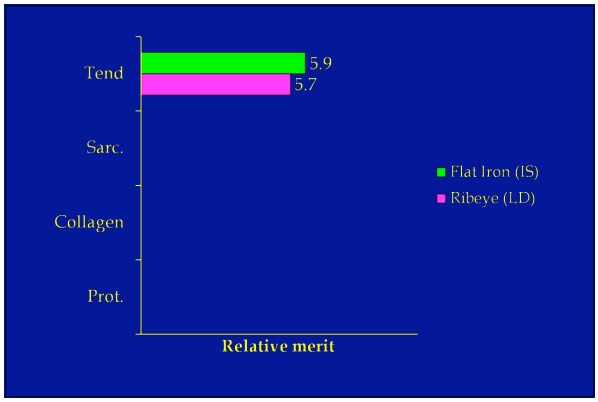
1. Sarcomere Length
2. Proteolysis
3. Connective tissue (collagen)

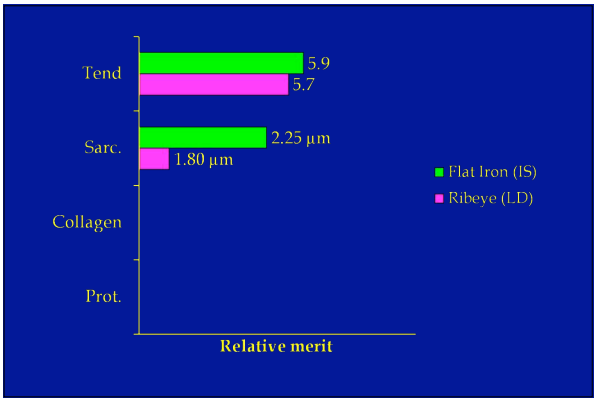
Effect of muscle on collagen concentration

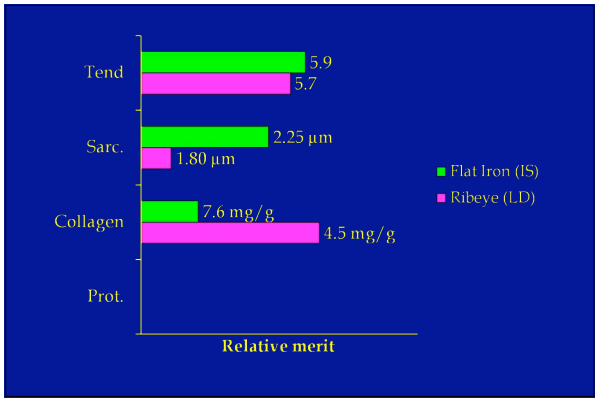


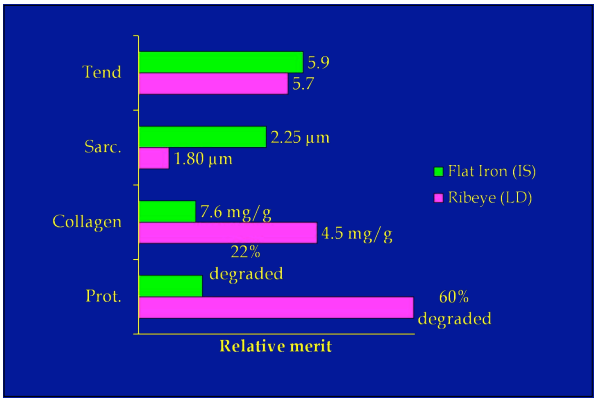

Effect of muscle on sarcomere length
Psoas major
Triceps brachii
Infraspinatus
Rectus femoris
Semitendinosus
Supraspinatus
Adductor
Biceps femoris
Semimembranosus
Longissimus
Gluteus medius
1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0
Sarcomere length of cooked muscle, µm


Effect of muscle on proteolysis (aging)
Biceps femoris
Longissimus
Semimembranosus
Gluteus medius
Semitendinosus
Triceps brachii
Rectus femoris
Adductor
Infraspinatus
Supraspinatus
Psoas major
0 10 20 30 40 50 60 70
Percentage of desmin degraded during aging


Tend
Sarc.
Collagen
Prot.
5.9
5.7
Flat Iron (IS)
Ribeye (LD)
Relative merit


Tend
Sarc.
Collagen
Prot.
5.9
5.7
2.25 µm
1.80 µm
Flat Iron (IS)
Ribeye (LD)
Relative merit


Tend
Sarc.
Collagen
Prot.
5.9
5.7
2.25 µm
1.80 µm
7.6 mg/g
4.5 mg/g
Flat Iron (IS)
Ribeye (LD)
Relative merit


Tend
Sarc.
Collagen
Prot.
5.9
5.7
2.25 µm
1.80 µm
7.6 mg/g
4.5 mg/g
22%
degraded
60%
degraded
Flat Iron (IS)
Ribeye (LD)
Relative merit

Muscle specific strategies can be developed to improve tenderness problems

Tenderness-based beef classification

Tools for Development of a Guaranteed Tender Program

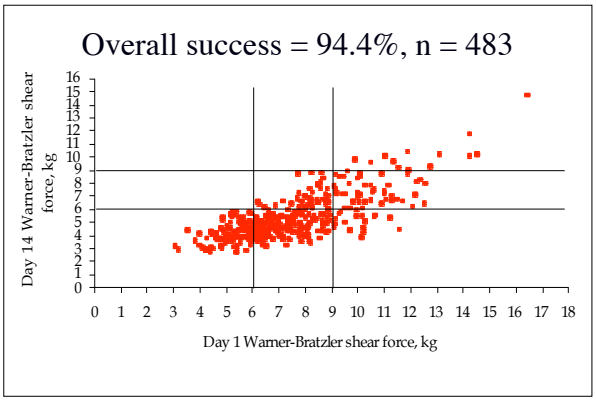
USMARC
Beef Classification System

USMARC Beef Classification System – Belt Grill Broiling

USMARC – Slice Shear Force

Slice Shear Force taken at 2 days postmortem was moderately correlated (r = .68) with 14 day shear force and classification for tender steaks was 85 to 95% accurate (Shackelford et al., 1997).

Recent summary: 1647 carcasses
64% classified as tender
(94% accurate)
9% classified as tough
(38% accurate)
27% intermediate?



The USMARC Beef Classification System is now used in a very successful program by a major US beef processor to provide guaranteed tender beef to the consumers of a major US retailer.

Industry wants to sort for tenderness to improve consistency of premium brands

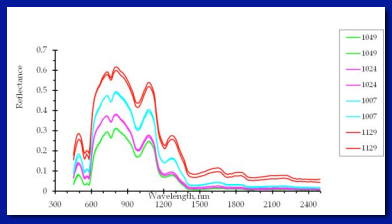
BUT

Will not use an invasive system

On-Line Tenderness Technology Requirements

- Accurate
- Fast (10 seconds or less)
- Durable – withstand plant environment
- Reasonably priced (noninvasive?)
- Reflect tenderness with advanced aging (i.e., 14 to 21 days postmortem)

Using Near Infrared Spectroscopy to Develop a Guaranteed Tender Beef Program



USMARC Non-invasive Beef Tenderness Prediction System

Project	% Tough (SSF > 25 kg)		
	Predicted Tender	Not Certified	Total
Plant A	4.4% (n=114)	14.7% (n=34)	7% (n=148)
Plant B	1.7% (n=118)	16.6% (n=18)	4% (n=136)
Plant C	0.0% (n=144)	0.0% (n=2)	0% (n=146)
Plant D	6.2% (n=130)	31.2% (n=16)	9% (n=146)
Overall	3.0% (n=506)	18.6% (n=70)	5% (n=576)

USMARC Non-invasive Beef Tenderness Prediction System

- It is too expensive

IEH TenderScopeTM

- We have just completed the development of an improved NIR-based system to predict beef tenderness and are ready for field testing.
- This instrument will be more flexible (more applications) and at a fraction of the cost of the existing instruments.

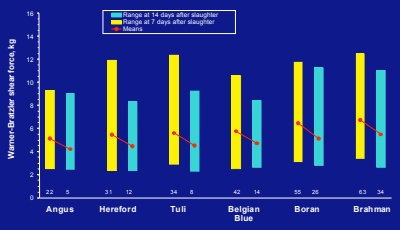
Meeting Consumer expectation – short term

- The correct genetics (no more than 25% unscreened *Bos Indicus).*
- Do not use implant with negative effect of tenderness
- Avoid aggressive implant strategies.
- Proper days on feed (~90 days)
- Proper handling/shipping to packing plant to minimize stress.

Meeting Consumer expectation – short term

- High voltage/frequency Electrical stimulation
- 14-days of postmortem storage (single most important affecter)
- Could use USMARC invasive system to offer a guaranteed tender beef
- Provide preparation/cooking instructions and any other helpful information to consumers.

Breed and length of postmortem storage



Meeting Consumer expectation – Long term

- As in previous slide
- Sort for tenderness using non-invasive and genetic tools (genomic-based technology) – creaming tool to offer guaranteed tender beef

Meeting Consumer expectation – Long term

- Genetics is a significant determinant of tenderness ($h^2 = 0.30$).
- Thus if the results of tenderness screens are shared with the seedsock producers, the national heard tenderness will be improved.

The Decline in Beef Demand (1980-1997)

Beef Demand

- **"**What is happening in substitutes like pork and chicken *can change beef demand, but it is not* cheap pork and chicken that is to blame for the prolonged problems in beef—there has to be something else."
- *Consumers, voting with their food dollars, told the beef industry that they did not liked the fresh beef offering.*

A Primer on Beef Demand – W. D. Purcell

Beef Demand

- "If what you are offering is allowed to diverge from what a changing consumer wants, you will be in trouble, you can expect price declines--and something needs to be done before even more market share is lost."

A Primer on Beef Demand – W. D. Purcell

It is NOT price

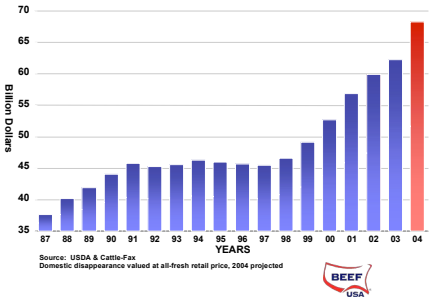
Year	Retail Price	CPI	Inflation-Adj Price
1990	$2.81	1.31	$2.14
1991	$2.88	1.36	$2.12
1992	$2.85	1.40	$2.04
1993	$2.93	1.45	$2.02
1994	$2.83	1.48	$1.91
1995	$2.84	1.52	$1.87
1996	$2.80	1.57	$1.78
1997	$2.80	1.61	$1.74

$2.14 – $1.74/$2.14 = 18.7% Decline in demand in spite of declining prices

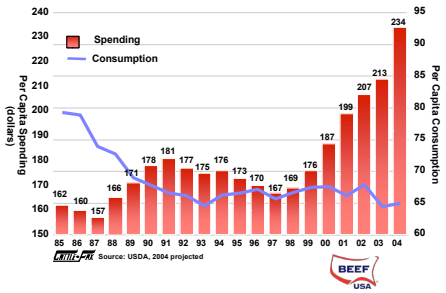
What is it then?

- Producing a product that did not meet consumer demands:
  - unacceptable frequency tough beef (1 out of 4 by some estimates)
  - Impression of unsafe product - Tenderness was a problem WELL BEFORE E. coli O157:H7 became an issue.

U.S. consumer expenditures on beef



Per capita beef spending and consumption



How was it done?

- The industry gave consumer what they wanted –
  - Safe
  - Tender
  - Consistent quality
  - Convenient to prepare

How was it done?

- Industry set tenderness goals (20% improvement in 10 years)
- Expulsion in branded products (Packers and retailers are willing to put their name on the package – something that they were not willing to do before)
- Guaranteed tender
- Tremendous focus on food safety
- From 1997 to 2003, 2100 new beef products were introduced.

Lessons learned

- The industry cannot afford to forget the lessons learned, it can do so at its own peril.

Improve Tenderness at the National Herd Level

- Food Safety Model -

Thanks for listening

Any Questions?