Meat Quality Research at USMARC

Tommy Wheeler, Steven Shackelford, and Andy King

USDA-ARS
U.S. Meat Animal Research Center
Clay Center, NE

We focus more on tenderness than other eating quality traits

USDA Certified Tender Program

★ USDA ★ TENDER

< 20 kg SSF

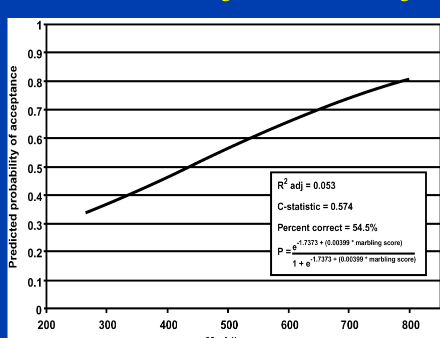
★ USDA ★ VERY TENDER

< 15.4 kg SSF

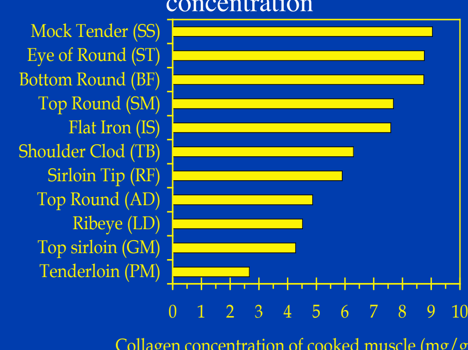
Biological basis for variation in meat tenderness

- Marbling
- Contractile state
- Enzymatic degradation of proteins
- Connective tissue

Consumer Like Ratings related to marbling



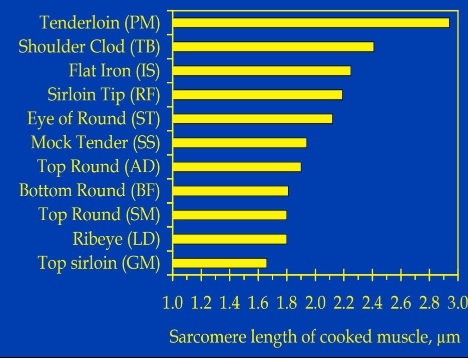
Effect of muscle on collagen concentration



Contractile State

Extent of muscle shortening during rigor mortis formation

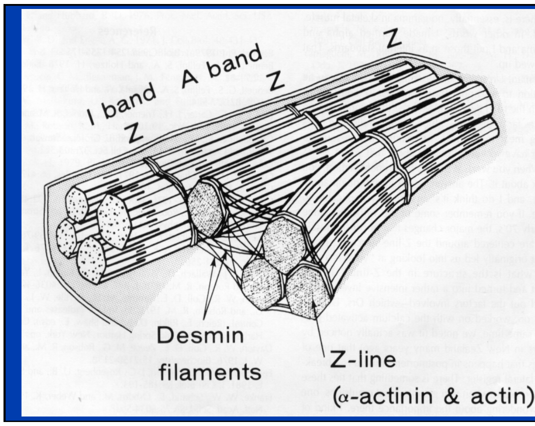
Effect of muscle on sarcomere length



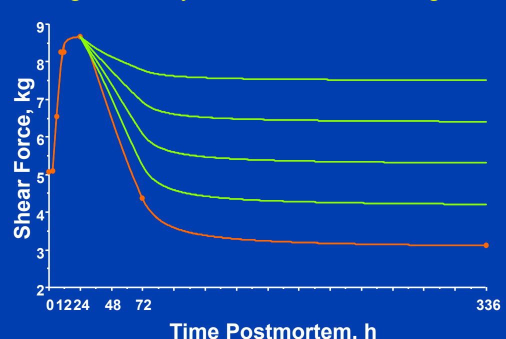
Enzymatic breakdown of protein (proteolysis)

The Calpain Proteolytic System

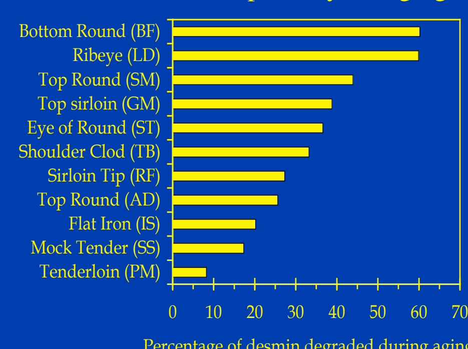
- µ-calpain
- m-calpain
- calpastatin



Changes in Ribeye Tenderness After Slaughter

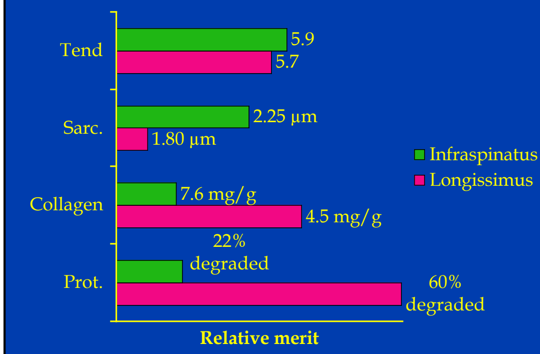


Effect of muscle on proteolysis (aging)



Tenderness Among Muscles

The relative contribution of extent of muscle shortening, connective tissue, and the extent of postmortem proteolysis is muscle dependent.



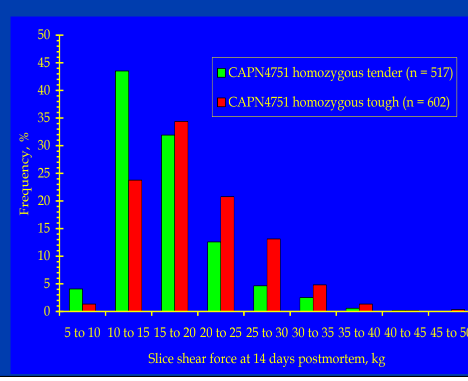
GPE Breed Summary

More Tender	Sl mor e Tender	Average	Slightly less Tender	Less Tender
• Pinzgauer • Piedmontese • Jersey • South Devon • Red Poll	• Angus	• All others	• Brangus • Charolais • Gelbvieh	• Sahiwal • Nellore • Brahman • Boran • Beefmaster

Genetic Markers for Meat Tenderness

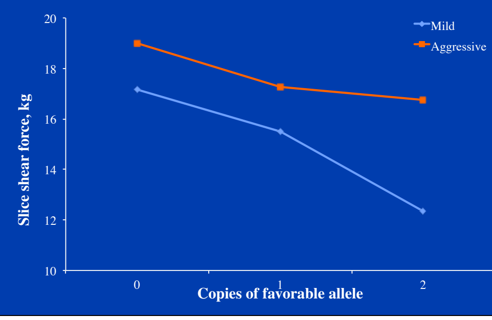
We have validated the tenderness markers in commercial populations

Effect of μ-calpain (CAPN4751) genotype on beef tenderness



Effect of Implants on Tenderness

Effects of CAPN1_316 in cattle treated with differing implant protocols



Effect of Beta Agonists on Tenderness

Table 1. Effects of crude protein (CP) level, ractopamine hydrochloride (RH) inclusion rate, and their interaction on beef LM slice shear force (SSF) at 14 d postmortem, the frequency of samples with LM SSF > 25 kg, and the frequency of carcasses predicted tender with visible and near-infrared (VISNIR) spectroscopy (Exp. 1; n = 16 pens)

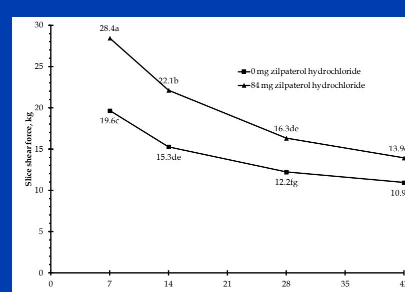
Factor	LM SSF at 14 d postmortem, kg	Frequency of samples with LM SSF > 25 kg, %	Frequency of carcasses predicted tender with VISNIR, %
CP Level (%)[1]			
13.5	14.6	0.4	95.5
17.5	14.9	1.8	95.1
SEM	0.4	0.7	1.7
P > F	0.61	0.23	0.87
RH inclusion rate ($mg \cdot hd^{-1} \cdot d^{-1}$)			
0	14.1	0.9	95.6
300	15.4	1.3	95.1
SEM	0.4	0.7	1.7
P > F	0.03	0.66	0.84
CP × RH interaction			
13.5% CP, 0 mg·RH $hd^{-1} \cdot d^{-1}$	14.4	0.9	95.6
13.5% CP, 300 mg·RH $hd^{-1} \cdot d^{-1}$	14.8	0.0	95.5
17.5% CP, 0 mg·RH $hd^{-1} \cdot d^{-1}$	13.8	0.9	95.6
17.5% CP, 300 mg·RH $hd^{-1} \cdot d^{-1}$	15.9	2.7	94.7
SEM	0.5	1.0	2.4
P > F	0.16	0.23	0.87

[1]Differential CP levels fed during the RH feeding period only (last 31 to 35 d before harvest).

Effects of zilpaterol hydrochloride (ZH) on beef LM slice shear force (SSF) at 14 d postmortem, the frequency of samples with LM SSF > 25 kg, and the frequency of carcasses predicted tender with visible and near-infrared (VISNIR) spectroscopy (n = 16 pens)

ZH status	LM SSF at 14 d postmortem, kg	Frequency of samples with LM SSF > 25 kg, %	Frequency of carcasses predicted tender with VISNIR, %
Control	16.2	3.6	92.3
Zilmax	24.2	39.3	57.7
SEM	0.6	4.1	3.1
P > F	0.0001	0.0001	0.0001

Interaction of Zilpaterol hydrochloride and postmortem aging period on LM SSF (*P* < 0.0001). Means not sharing a common letter differ (*P* < 0.05)



Current Beta Agonist Studies

- Optaflexx aging time
- Zilmax heat stress/mobility with UNL/ NBC
- Zilmax consumer study

Effect of Degree of Dark Cutting on Tenderness and Flavor Attributes of Beef

- Carcasses selected when presented for carcass grading
  - For each DC carcass, a normal cohort of similar marbling score was selected from the same production lot
- *Longissimus* pH was collected online and us classify into DC classes

-Severe DC	n=40	mean pH=6.9
-Moderate DC	n=40	mean pH=6.6
-Mild DC	n=40	mean pH=6.4
-Shady DC	n=40	mean pH=6.1
-Normal Cohort	n=160	mean pH=5.7

Least square means for slice shear force, sarcomere length, and desmin degradation percentage

Degree	Slice Shear Force (kg)	Sarcomere Length (µm)	Desmin Degradation (%)
Severe DC	16.8[a]	1.66[a]	49.20[a]
Moderate DC	19.4[a]	1.67[a]	40.31[a]
Mild DC	22.9[b]	1.71[ab]	42.07[a]
Shady DC	25.6[b]	1.73[b]	43.30[a]
Normal	17.8[a]	1.86[c]	59.83[b]

Least square means for trained sensory panel descriptive flavor attribute analysis

Degree	Rancid	Musty
Severe DC	0.33[a]	0.25[a]
Moderate DC	0.32[a]	0.26[a]
Mild DC	0.20[b]	0.11[b]
Shady DC	0.10[c]	0.08[bc]
Normal	0.08[c]	0.03[c]

Conclusion

- Dark cutting carcasses differed in tenderness, juiciness, and flavor attributes
  - Direction/magnitude dependant upon severity of DC
  - Severe and moderate DC were higher in "off-flavors"
- Shady dark cutters are most likely to be tough
  - Included in U.S Select and U.S. Choice product lines

Freeze/Age

Can we take advantage of what we know about the calpain system and its inhibitor calpastatin?

Effect of freezing or freezing, thawing, and aging on slice shear force

	Longissimus		Semitendinosus	
Treatment	SSF	%>25kg	SSF	%>25kg
Fresh 2d	33.1^a	100	29.2^a	83
Freeze 2d	27.4^b	57	24.5^b	40
Freeze 2/Age 12	17.8^d	0	20.8^c	6
Fresh 14d	25.3^b	46	25.5^b	49
Freeze 14d	22.4^c	26	22.4^c	34
Freeze 14/Age 14	14.6^e	3	19.0^d	0
Fresh 28d	18.7^d	11	21.7^c	17

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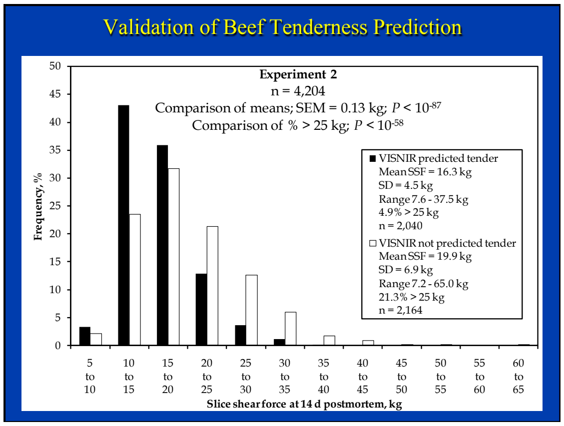
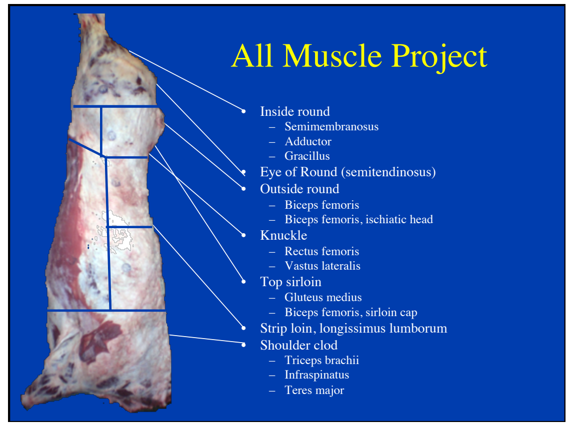
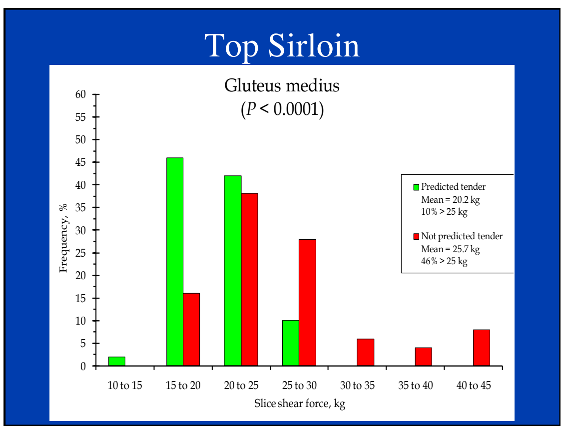
Predicting Tenderness

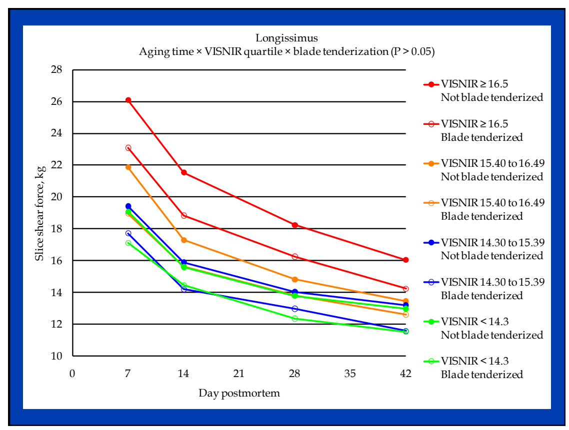
The USMARC Beef Tenderness System

Use of visible and near-infrared reflectance to predict beef tenderness

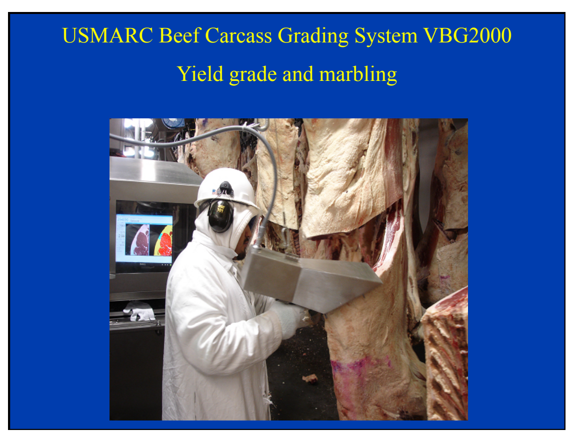

Validation of Beef Tenderness Prediction
Experiment 2
n = 4,204
Comparison of means; SEM = 0.13 kg; P < 10-87
Comparison of % > 25 kg; P < 10-58
VISNIR predicted tender
Mean SSF = 16.3 kg
SD = 4.5 kg
Range 7.6 - 37.5 kg
4.9% > 25 kg
n = 2,040
VISNIR not predicted tender
Mean SSF = 19.9 kg
SD = 6.9 kg
Range 7.2 - 65.0 kg
21.3% > 25 kg
n = 2,164
Frequency, %
Slice shear force at 14 d postmortem, kg


All Muscle Project
Inside round
– Semimembranosus
– Adductor
– Gracillus
Eye of Round (semitendinosus)
Outside round
– Biceps femoris
– Biceps femoris, ischiatic head
Knuckle
– Rectus femoris
– Vastus lateralis
Top sirloin
– Gluteus medius
– Biceps femoris, sirloin cap
Strip loin, longissimus lumborum
Shoulder clod
– Triceps brachii
– Infraspinatus
– Teres major


Top Sirloin
Gluteus medius
(P < 0.0001)
Predicted tender
Mean = 20.2 kg
10% > 25 kg
Not predicted tender
Mean = 25.7 kg
46% > 25 kg
Frequency, %
10 to 15
15 to 20
20 to 25
25 to 30
30 to 35
35 to 40
40 to 45
Slice shear force, kg


Longissimus
Aging time × VISNIR quartile × blade tenderization (P > 0.05)
VISNIR ≥ 16.5 Not blade tenderized
VISNIR ≥ 16.5 Blade tenderized
VISNIR 15.40 to 16.49 Not blade tenderized
VISNIR 15.40 to 16.49 Blade tenderized
VISNIR 14.30 to 15.39 Not blade tenderized
VISNIR 14.30 to 15.39 Blade tenderized
VISNIR < 14.3 Not blade tenderized
VISNIR < 14.3 Blade tenderized
Slice shear force, kg
Day postmortem


Beef carcass tenderness grading


USMARC Beef Carcass Grading System VBG2000
Yield grade and marbling

Nolan Ryan Tender Aged Beef

Lean Color Stability in the Retail Case

Animal differences in color stability