Live Animal Tissue Evaluation with Ultrasound

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Why Use Ultrasound?

Ultrasound is a non-invasive procedure that is humane and provides a quantitative way to evaluate muscle and fatty tissue, and also to determine pregnancy.

The relationship between ultrasound data and actual carcass data is similar and can be used to make genetic selection and improvement.

Benefits for Using Real-Time Ultrasound in Beef Cattle:

Genetic Evaluation and Carcass Expected Progeny Difference (EPD)
Slaughter End Point: Ribeye area, Fat Depth, and % Intramuscular Fat (IMF; Marbling)
Pregnancy Determination and Fetal Aging

Ultrasound measurements of fat and muscle are used by the seed-stock industry to provide cattlemen with information about potential sires to change the genetic population of cattle.

Ultrasound is important for assisting in genetic selection that will improve carcass yield grade and quality grade. Improvement in carcass quality grade is important, because quality improves the eating experience people want. It is the upper two-thirds of Choice and Prime quality grades that deliver the eating experience people want.

How Does Ultrasound Work?

Ultrasonic sound waves are generated by the ultrasound transducer. Piezoelectric crystals in the transducer (probe), which are made from crystalline quartz, tourmaline or man-made ceramics, are used to convert electrical energy into ultrasound.

The transducer, or probe, is an instrument attached to the ultrasound equipment that captures a thin slice of the sample and displays it on the screen. The transducer generates ultrasound and then it sends and receives the ultrasonic waves. Ultrasound - sound waves that have a frequency beyond the audible range for human ears. Humans can hear at frequencies between 20 to 20,000 hertz. Ultrasound is sound waves above 20,000 hertz.

The ultrasound is emitted from the probe in short pulses. The sound field resulting from the ultrasound pulses is called a beam.

The beam is divided into two regions called the "near" and "far" fields, which are important in beam focusing. These short pulses of ultrasound are reflected and scattered by tissues and tissue

interfaces. Some of the sound waves penetrate the tissues and others are reflected back to the probe (echoes).
The echoes that return to the probe are detected and displayed on the ultrasound on the ultrasound unit screen in a cross-sectional anatomical format in shades of grey from white to black.

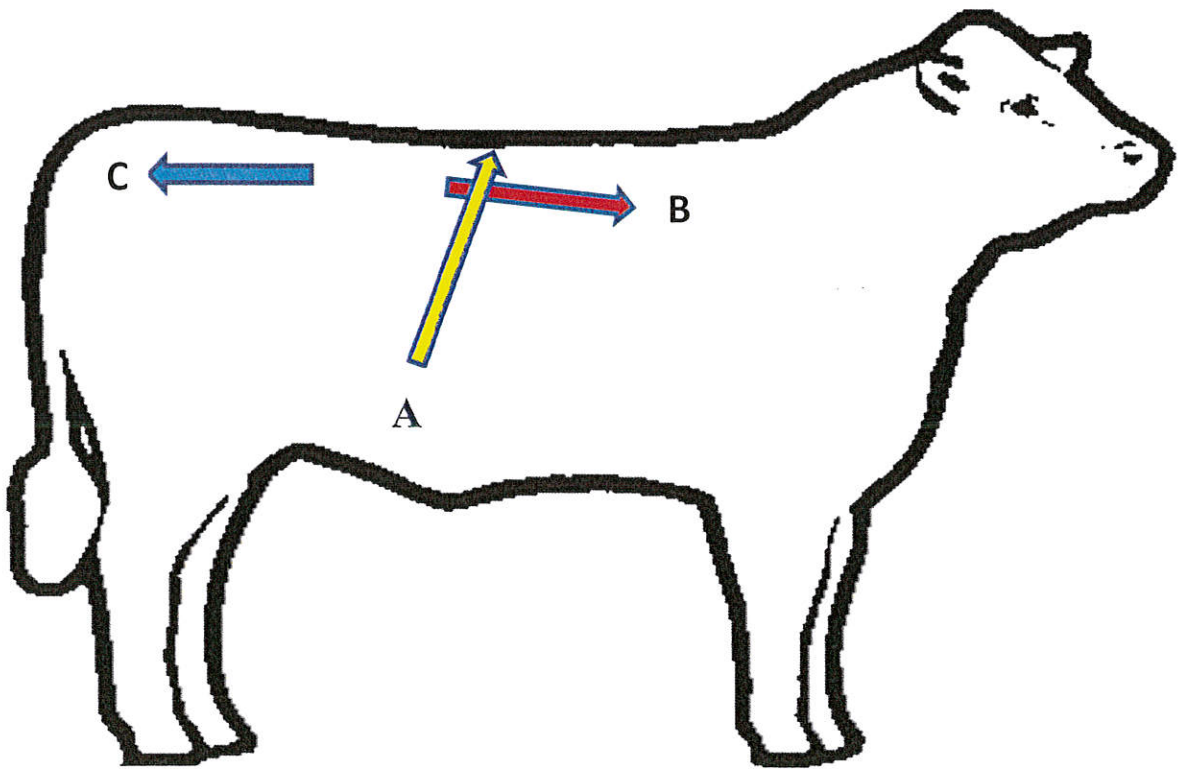
The images can be analyzed and conclusions drawn regarding anatomy, health status, physical characteristics such as ribeye area, fat thickness, intramuscular fat, and external fat thickness, etc.

Are Different Probes (Transducers) Used for Different Applications?

Yes. Different applications require different frequencies.
For example: A- Reproduction applications require a 7.5 MHz transducer.
This transducer has short wavelength, low penetration, and high resolution
B- Live animal carcass composition applications require a 3.5 MHz transducer.
This transducer has long wave length, deep penetration, and poor resolution

Transducers are fragile and very expensive.

What Live Animal Carcass Images Are Commonly Collected?



- Measurements taken between the 12th and 13th ribs
  - A- Longissimus dorsi muscle area (ribeye area) (Fig. 1)
  - B- Percent intramuscular fat (marbling) (Fig. 2)
  - C- Body fat thickness (Fig. 2 and 3)

Ribeye Area (REA)

Ribeye area (REA) is the area of the *longissimus* dorsi muscle or ribeye muscle and is measured by including only the area of the *longissimus dorsi* muscle. You should not include any other muscles (e.g. *spinalis dorsi* or *longissimus costarum*) in the interpretation. It is measured in square inches or square centimeters between the 12th and 13th ribs. The normal REA ranges from approximately 8.0 to 16.0 in^2 in yearling cattle. The guideline for estimating REA on live beef animals is 1.10 in^2 / 100 pounds of body weight up to 1000 pounds and 1.0 in^2 / 100 pounds of body weight over 1000 pounds. On average, a 1000 lb. steer should have an 11.0 in^2 REA and a 1100 pound steer would have a 12.0 in^2 REA. REA is positively correlated with pounds of retail product. Within a specific carcass weight range, REA may have a significant impact on the variation in beef carcass yield grades. REA is moderate to highly heritable (Fig.1).

Marbling (Intramuscular Fat, MAR)

Marbling (Intramuscular Fat) may be objectively measured in live cattle using real-time ultrasound and is reported as percent fat in the ribeye muscle. Percent fat correlates with a USDA grader's subjective visual evaluation of marbling in a beef carcass and is the primary component for carcass quality pricing. Heritability of marbling is moderate. There is a relatively high correlation ($r = .75$) between ultrasound prediction of percent fat in the live animal and the actual percent fat in the carcass ribeye according to research studies, although marbling can be assessed with somewhat less accuracy than fat thickness and LMA in live cattle, ultrasound gives us the opportunity to objectively measure this economically important trait. Bulls will have a lower percent intramuscular fat than steers or heifers of equivalent age, management and genetic potential. Research studies have shown that the genetic correlation between marbling and fat thickness are very low, suggesting that selection for improved quality grades can be obtained without an increase in external fat and associated lower cut ability (Fig.2).

Rump Fat Thickness (RFU)

Rump fat thickness (RFU) measures the depth of subcutaneous fat at the juncture of the *gluteus medius* and *biceps femoris* muscles. Rump fat is an additional fat measurement that is collected because animals deposit fat at different rates in different locations. Rump fat measurements are the most highly repeatable (Fig.3).

Fat Thickness (FT)

Fat thickness (FT) is an assessment of external fat on the carcass and is measured over the *longissimus dorsi* at a point ¾ of the distance from the medial (spine) side to the lateral side of the muscle. FT, along with *longissimus* muscle area, is highly correlated to the retail product yield of a beef carcass. Greater fat thickness depth results in lower percent retail product in the carcass. The yield grade also increases numerically toward 5. FT accounts for the majority of the variation found in beef carcass yield grades. FT is moderate to highly heritable (Fig.1).

Yield Grade

Yield grade is a USDA measurement for cut ability or the amount of saleable and edible product in a beef carcass. Yield grade is the estimate of the yield from a beef animal carcass of closely trimmed, boneless, retail cuts. Yield grade is based on hot carcass weight, ribeye area at the 12^{th} and 13^{th} rib interface, fat thickness at the 12^{th} and 13^{th} rib interface, and the estimate of kidney, pelvic and heart fat. Yield grade is calculated as follows: YG = 2.5 + 2.5 (fat thickness, inches) + 0.2 (percent kidney, pelvic, heart fat) + 0.0038 (hot carcass weight, pounds) – 0.32 (ribeye area, square inches). USDA yield grade #1 would have the highest yield of closely trimmed retail cuts and yield grade #5 would have the lowest yield of closely trimmed retail cuts.

Quality Grade

USDA quality grades for beef carcasses are based on estimation of physiological age of the animal at the time of slaughter (maturity), color and texture of longissimus muscle area at the 12 -13^{th} rib interface, ossification of cartilage in the skeletal system and by the estimated amount and distribution of marbling in the exposed longissimus muscle (Table 1).

Fig. 1. Longissimus dorsi muscle Image – (Ribeye Area)

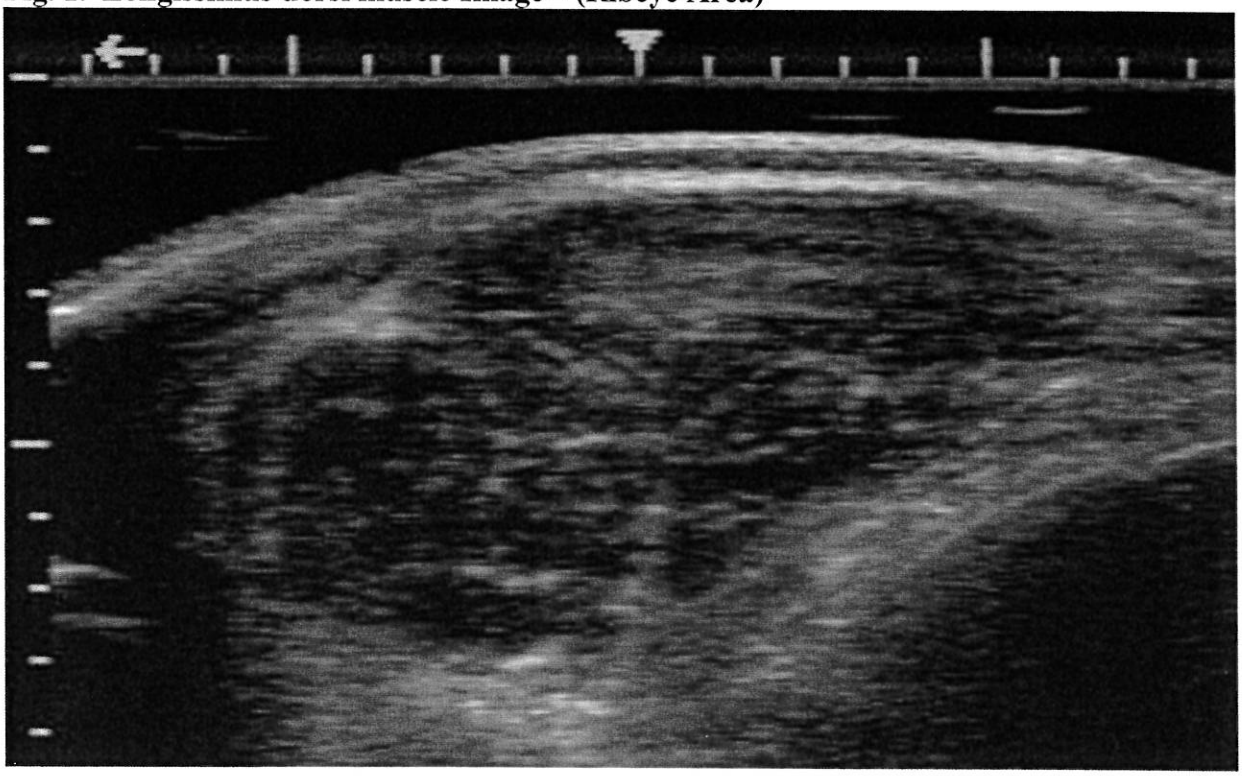


Fig. 2. Intramuscular Fat Image (Marbling)

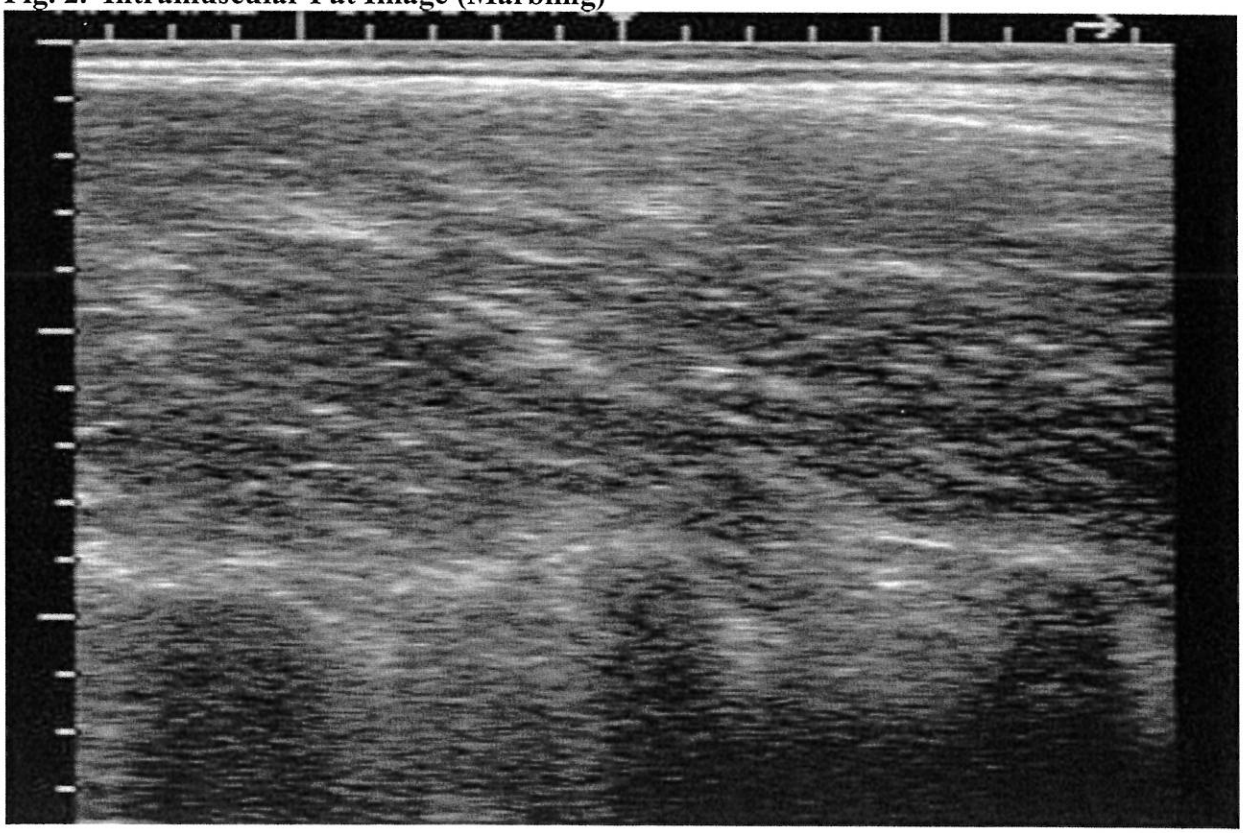
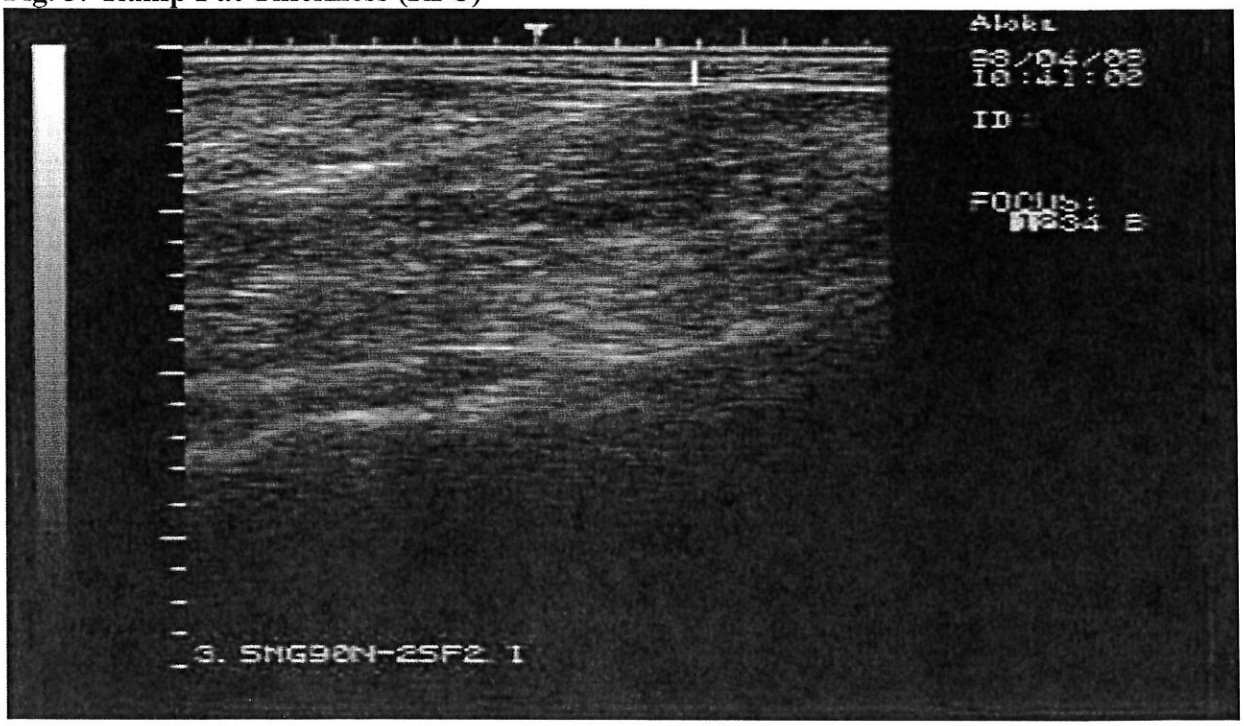


Fig. 3. Rump Fat Thickness (RFU)



Ultrasound measurements are used to calculate individual EPD values for economically important carcass traits and are shown in the sale catalog examples below as MAR – Marbling, REA – Ribeye

5L ADVOCATE 1687-181Y

167

02/26/2011 1A — 100.0% FLR / 181Y # 1450066

5L NORSEMAN KING 2291 [MAF,OSF]
5L SIGNATURE 5615 [OSC]
5L RUBY 199-01 [OSC]
5L ADVOCATE 817-14W (#1330290) [OSF]
5L HERITAGE 1821-5985 [MAF,OSF]
5L MARTA 345-817 [OSF]
5L MARTA 1563-345

5L DIRECT FIRE 1641-6443 [AMF,MAF,NHF,OSF]
5L DESTINATION 893-6215 [AMF,NHF,OSF]
5L ADINA 525-893 [OSF]
5L FIREFLY 275-1687 (#1187056) [OSF]
5L NORSEMAN KING 2291 [MAF,OSF]
5L FIREFLY 2573-275
5L FIREFLY 190-2573 [OSF]

BW	80
WW	647
YW	1112

CED	BW	WW	YW	MILK	TM	ME	HPG	CEM	STAY	MAR	YG	CW	REA	BF
5	1.8	44	79	17	39	1	13	3	10	0.62	-0.01	52	0.28	0.01
43%	85%	13%	16%	56%	19%	28%	7%	58%	54%	1%	53%	9%	15%	62%

Wide Body Score 7.0 *Age of Dam: 4.*

Lot 167... Very strong carcass merit out of a Destination daughter we think a lot of

5L RIGHT KIND 1139-412Y

168

03/28/2011 1A — 100.0% FLR / 412Y # 1449965

BECKTON LANCER F442 T [MAF,OSF]
BUF CRK LANCER R017 [MAF,OSF]
BUF CRK JULIET N036 [OSC]
BUF CRK THE RIGHT KIND U199 (#1260155) [OSF]
BUF CRK JULIAN L080
BUF CRK SHOSHONE R353 [OSF]
BUF CRK SHOSHONI 6410 [OSF]

5L DESTINATION 893-6215 [AMF,NHF,OSF]
5L SUMMIT 1145-6327 [MAF,OSF]
5L HAZEL 203-1145 [OSF]
5L ADINA 437-1139 (#1314668) [OSF]
5L SIGNATURE 5615 [OSC]
5L ADINA 1215-437 [OSC]
5L ADINA 525-1215 [OSF]

BW	ET
WW	635
YW	1120

CED	BW	WW	YW	MILK	TM	ME	HPG	CEM	STAY	MAR	YG	CW	REA	BF
8	-0.6	38	70	15	34	-1	14	5	15	0.22	-0.03	42	0.14	0.00
20%	40%	33%	31%	73%	53%	11%	5%	31%	7%	18%	43%	36%	35%	43%

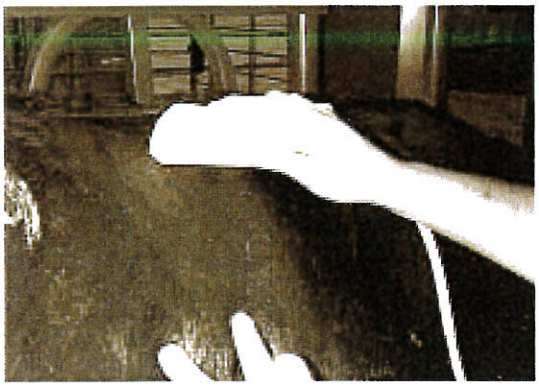
Wide Body Score 7.0 *Age of Dam 2. ET Recip: X7122.*

Lot 168... Here's a Right Kind son that has all the pedigree pieces in place. Great Balanced EPD's

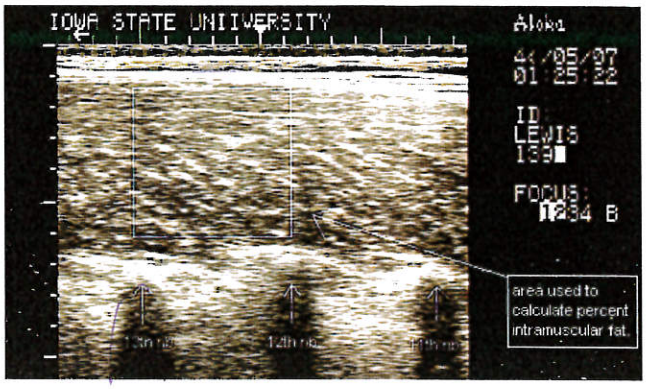
Calving Ease Direct (**CED**)
Heifer Pregnancy (**HPG**)
Calving Ease Maternal (**CEM**)
Stayability (**STAY**)
Yield Grade (**YG**)

Ribeye Area (**REA**)
Marbling (**MAR**)
Birth Weight (**BW**)
Weaning Weight (**WW**)
Yearling Weight (**YW**)

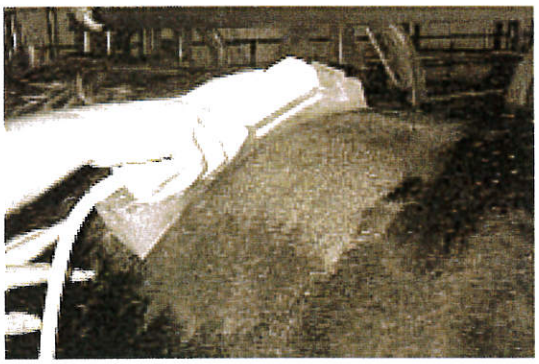
Total maternal (**TM**)
Maintenance Energy (**ME**)
Carcass Weight (**CW**)
Back Fat (**BF**)
MILK



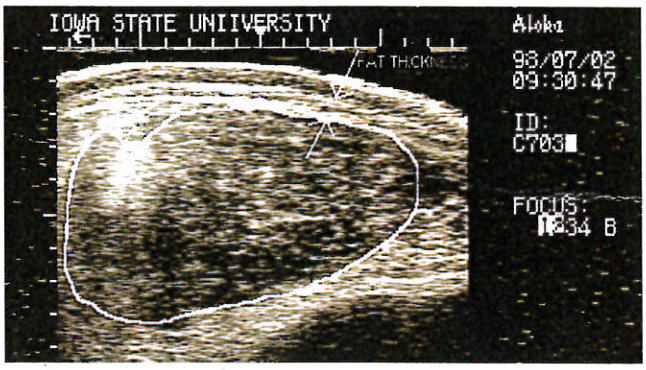
Reference 1. The technician is collecting the across image shown on the right for calculation of percent intramuscular fat (marbling).



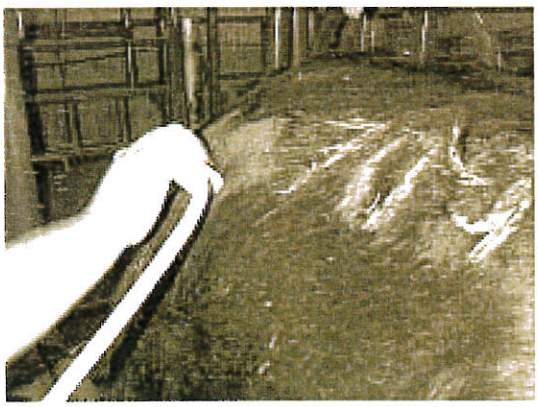
Real-time ultrasound image collected the 11,12, & 13th ribs.



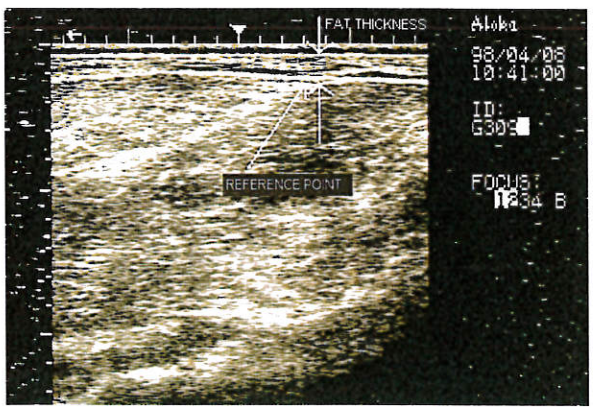
Reference 2. The technician is collecting the image shown on the right for measurement of ribeye area and the 12-13th rib fat thickness.



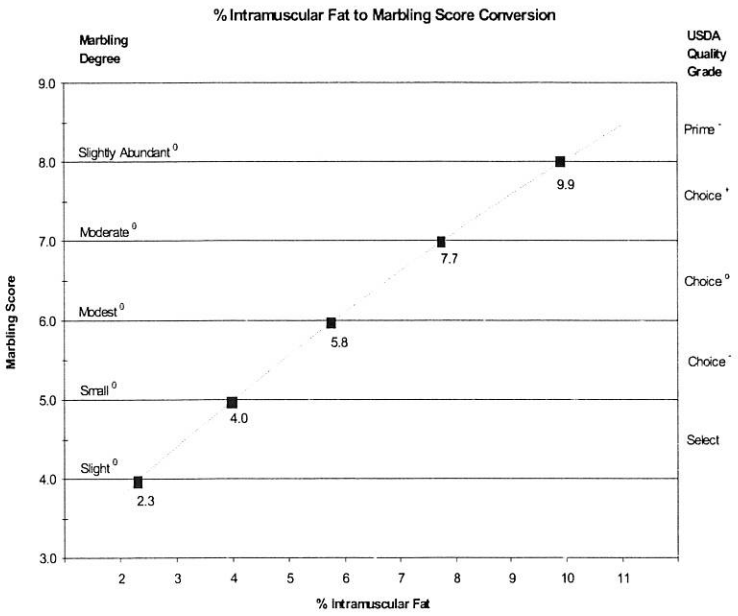
Real-time ultrasound image collected between the 12-13th rib.



Reference 3. The technician is collecting the image shown on the right for calculation of rump fat thickness.



Real-time ultrasound image collected across the rump.



Marbling is measured as percent fat. Beef carcasses are traded on the amount of intramuscular fat (marbling) they contain between the 12-13th ribs. However, marbling is a very subjective score. Real-time ultrasound has the capability to objectively predict the actual percent intramuscular fat in the ribeye, which is what the grader is trying to visually evaluate.

This graph relates percent intramuscular fat to amounts of marbling in the USDA Quality Grading system.

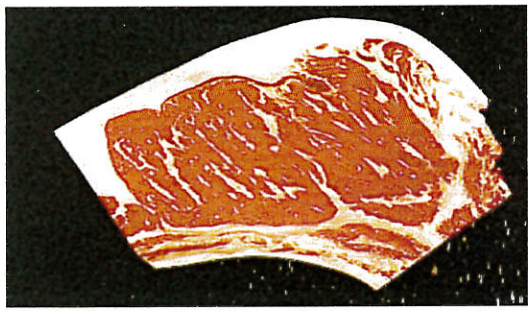
Table 1. % Intramuscular Fat to Marbling Score Conversion

Percent Intramuscular Fat	Quality Grade	Marbling Degree	Marbling Score
2.3 - 3.0	Select -	Slight 0 - 40	4.0 - 4.4
3.1 - 3.9	Select +	Slight 50 - 90	4.5 - 4.9
4.0 - 5.7	Choice -	Small 0 - 90	5.0 - 5.9
5.8 - 7.6	Choice o	Modest 0 - 90	6.0 - 6.9
7.7 - 9.7	Choice +	Moderate 0 - 90	7.0 - 7.9
9.9 - 12.1	Prime -	Slightly Ab 0 - 90	8.0 - 8.9
12.3 -	Prime o	Moderately Ab 0 -	9.0 -

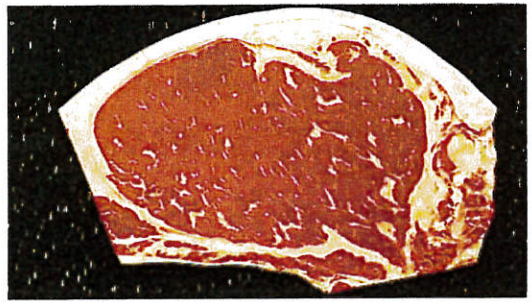
Prepared by Doyle E. Wilson, Gene H. Rouse, Craig L. Hays, J. R. Tait, and Jodi Kruser, Iowa State University, Department of Animal Science, Ames, Iowa.

Quality Grades: Relationship Between Degrees of Marbling and Carcass Maturity

Degrees of Marbling



Moderately Abundant

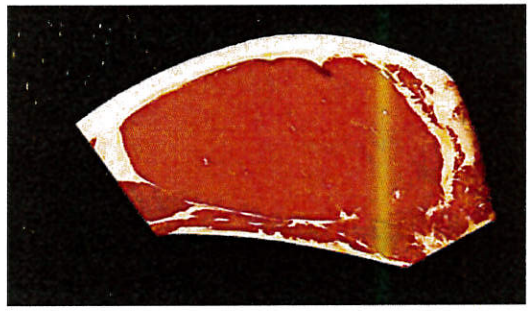


Slightly Abundant

Moderate

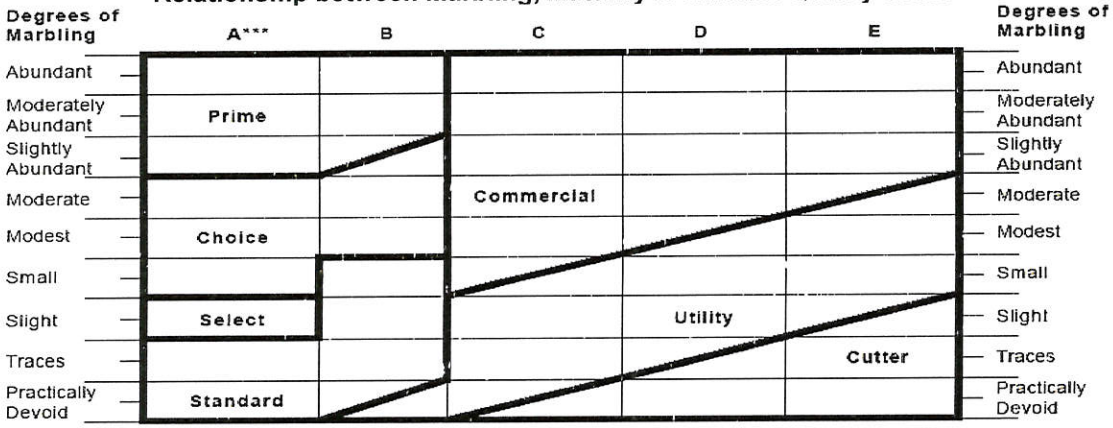
Modest

Small



Slight

Relationship between Marbling, Maturity & Carcass Quality Grade



USDA (1997) Standards for Grades of Slaughter Cattle and Standards for Grades of Carcass Beef

Relationship between Carcass Maturity & Approximate Live Age

Carcass Maturity	Approximate Live Age
A	9-30 months
B	30-42 months
C	42-72 months
D	72-96 months
E	> 96 months

National Daily Cattle and Beef Summary
Des Moines, Iowa **Thursday, August 15, 2013** **USDA Livestock & Grain Market News**

LM_XB403

DAILY ESTIMATED CUTOUT VALUES

	Choice 600-900#	Select 600-900#
Cutout Values	193.30	185.71
Change from Prior Day	0.95	1.01
Primal Rib	300.97	276.28
Primal Chuck	162.71	161.87
Primal Round	164.76	163.65
Primal Loin	250.04	230.04
Primal Brisket	140.60	138.74
Primal Short Plate	141.16	142.80
Primal Flank	122.56	119.85

Choice/Select Spread
7.59

Load Count:

Total	129
Choice	46
Select	45
Trimmings	10
Grinds	27

Fresh 50% Trimmings 10 Loads @ 109.10

NW_LS441

USDA BY-PRODUCT DROP VALUE (STEER)
Value: 14.25 Change: 0.05

LM_CT100

5 AREA WEEKLY ACCUMULATED WEIGHTED AVG CATTLE PRICE

	Head Count	Avg Weight	Avg Price
Live Steer	139	1,393	123.24
Live Heifer	68	1,300	123.00
Dressed Steer	349	853	197.37
Dressed Heifer	399	816	197.00

SJ_LS710

ESTIMATED DAILY CATTLE SLAUGHTER

Today (est)	123,000	
Week Ago (est)	122,000	
Year Ago (act)	126,000	
Week to Date (est)	481,000	
Same Period Last Week (est)	486,000	
Same Period Last Year (act)	502,000	
Previous Day Estimated	Steer and Heifer	98,000
	Cow and Bull	25,000

SJ_LS712

BEEF PRODUCTION	8/9/2013 (Estimate)	Last Week (Estimate)	Last Year (Actual)
Slaughter	633,000	625,000	640,000
Live Weights	1305	1304	1301
Dressed Weights	795	796	794
Beef Production (millions of pounds)	502.6	496.4	507.5

NW_LS410

USDA BEEF CARCASS PRICE EQUIVALENT INDEX VALUE

	Choice 600-900#	Select 600-900#	Dressing percent: Steer	Heifer
	180.01	172.87	64.35	64.31
Change	0.46	0.49		

LM_XB405

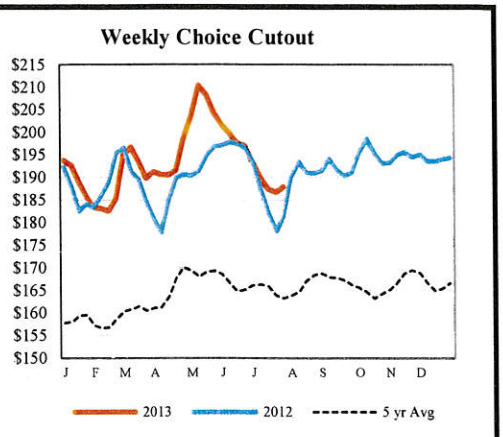
USDA NATIONAL CUTTER COW CARCASS CUTOUT
160.89 Change 0.31 90% lean: 201.02

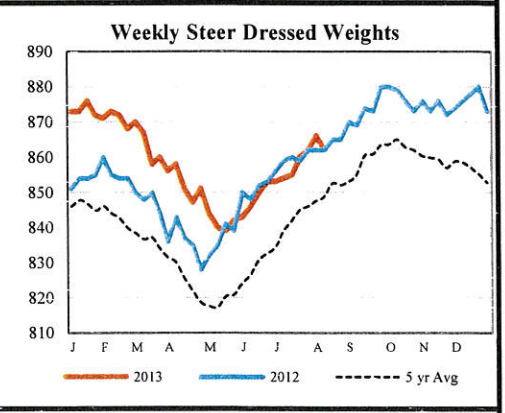
CME LIVE CATTLE

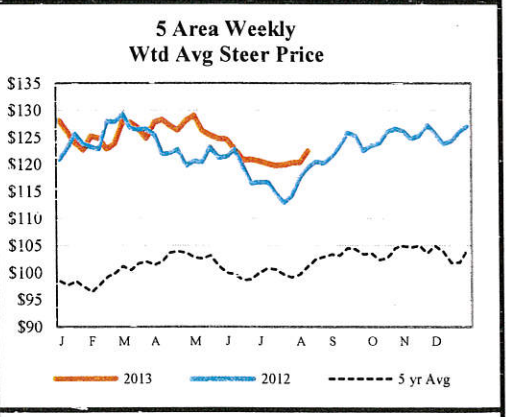
	High	Low	Close	Change
Aug	124.25	123.53	123.70	(0.30)
Oct	128.45	127.70	128.10	(0.08)
Dec	130.15	129.58	129.88	(0.13)

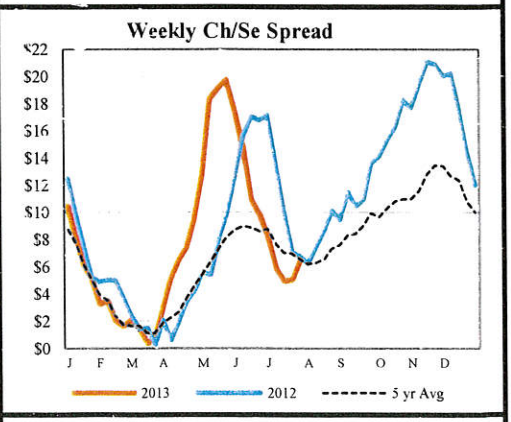
CME FEEDER CATTLE

	High	Low	Close	Change
Aug	154.28	153.20	154.10	0.50
Sep	157,85	156.80	157.08	(0.38)
Oct	160.23	159.00	159.35	(0.50)









USDA Livestock Poultry Grain Market News
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