Tenderness... Finding Genes that Fit

By Susan Willmon, AGA Director of Breed Improvement

Numerous beef industry studies over the past decade have shown that the typical beef consumer prefers a tender, juicy and flavorful beef eating experience. The most recent data that compared the tenderness of specific breeds was the Meat Animal Research Center (MARC) Germplasm Report 22. Unfortunately, data within this report listed the Gelbvieh-influenced cattle as the least tender of the seven breeds represented. While the differences between the continental breeds were not statistically significant, the difference between the least tender (Gelbvieh) and most tender (Angus) was significant at a net difference of 1.1 pounds of Warner-Bratzler Shear Force (WBSF). Since there is not much other current tenderness data available comparing breeds this report served as wakeup call to American Gelbvieh Association (AGA) members and Gelbvieh breeders.

At the April 2005 AGA Board meeting the decision was made to test the top 25 A.I. Gelbvieh sires for the available DNA Tenderness markers. While several technologies are available to evaluate tenderness, at present the DNA markers represent a cost-effective and potentially faster means of evaluating the genetics currently being used and effecting change for future generations compared to progeny carcass testing as a means of sire evaluation. The Board's decision was made based on the desire for this information to be made available to all producers and be used as a part of bull selection criteria. This initial testing was performed using Bovigen's DNA Tenderness panel, as they offered the ability to test for two different genes with a total of three markers for this trait.

On the page 77, you will find the results of the testing for the Top 25 sires. This data will be published on the Gelbvieh website and additional A.I. sires will be added on a yearly basis. The AGA membership set itself apart from every other breed in the United States by possessing this data on the top sires. Additionally on the website we will have a section for DNA results for other animals within the breed that have been tested for the various markers. The ultimate goal is to have this information available on as many animals within our breed as possible providing AGA members, as well as other producers using Gelbvieh genetics, a powerful tool to impact the tenderness of that ultimate end product—a Gelbvieh-influenced steak on a plate.

In this article you will find a DNA Tenderness Marker Reference Guide. Included in this information is an explanation of the individual genes, their effects on tenderness and the frequencies of the genes based on tested animals to date. Part of our challenge in possessing this information is to not only be able to use it in making breeding decisions, but to be able to explain its use to seedstock and commercial customers alike. While this technology is not new, understanding it possesses a somewhat steep learning curve and overall use among beef producers is still at a relatively low level. To increase the level of understanding, or at least minimize the confusion, it is recommended that results are advertised with a tag to their marker title. In the sample layout below, the number in parentheses corresponds to the marker value on the GeneSTAR results report and the letters correspond to the actual genotype.

Quality Grade		Tenderness		
TG5	M2	CAST	$CALP_{316}$	$CALP_{4751}$ (T3)
CT(1)	GG(0)	GA(1)	GG(0)	CC(2)

In order to make improvement in tenderness within our breed and the commercial cattle influenced by Gelbvieh genetics, breeding decisions must be made that improve the next generation's gene frequencies over what is currently present. The best way is to mate bulls with these markers to cow families that might lack them or using cow families that possess the markers to improve sire lines with lower frequencies. It does not mean selecting sires based solely on these values. An animal that possesses the Tenderness genes at the expense of growth, maternal or fertility traits will ultimately do more to hurt genetic progress than help it.

We are fortunate that within these Top 25 sires we see all of these genes in some form (See **Frequencies of DNA Markers** on page 76). It will be relatively simple to increase the frequency of both the Calpastatin (CAST) and Calpain 4751 (T3) markers, as we have a good foundation to work with. The Calpain 316 (CALP) marker presents more of a challenge but can be increased as well over time. We have also included the results for the Quality Grade markers. These markers will be discussed in Part 2 of this series in the April *Gelbvieh World*.
Bottom line is the total net increased Tenderness that can be obtained by putting some selection pressure on these markers is over two pounds. The difference between the least tender (Gelbvieh) and most tender (Angus) influenced cattle in the MARC study was just 1.1 pounds of WBSF. We can find the genes that fit in almost any breeding scenario and in a few generations greatly improve the ranking of Gelbvieh-influenced cattle in respect to tenderness.

DNA Tenderness Marker Reference Guide

As part of the Productivity Committee meeting at the 2006 AGA Convention in Denver, the following background information was presented on DNA Marker Technology as it exists currently.

Understanding the Tenderness DNA Markers

During the post-mortem aging process enzymes work to impact tenderness within the carcass. DNA Markers have been

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identified for two of these enzymes: Calpain and Calpastatin. Calpain is an enzyme, which works to break down muscle fibers during the aging process. The presence of Calpastatin works to block the effect of the Calpain enzyme. So basically the desired animal has the genetic code to produce Calpain and low levels of Calpastatin. This is what is commonly referred to as the "favorable" forms of both of these genes.

Table A.

STARS	FORM	CAST	$CALP_{316}$	$CALP_{4751}$ (T3)
2	Favorable	AA	CC	CC
1	Intermediate	GA	CG	CT
0	UN-Favorable	GG	GG	TT

The favorable forms of these genes are represented in Table A. Included in this table are both the "STAR" values that are represented in the GeneSTAR results, as well as the actual genotypes. By presenting the genotypes as well as a number value, breeders that have results from Igenity's Calpain test and other companies can compare results to the Calpain tests reported by Bovigen.

Calpastatin, abbreviated CAST, was the initial gene marker identified to effect tenderness and was first offered as a DNA Marker test in January 2003. As illustrated in Table A Bovigen reports this favorable form as a 2, the unfavorable form (higher levels of Calpastatin) as a 0. Table B reports the effects of these forms of Calpastatin based on Warner-Bratzler Shear Force (WBSF) tests.

Table B.

Calpastatin Effects		
Favorable Form	Intermediate	UN-Favorable Form
2 (AA)	1 (GA)	0 (GG)
-0.81	-0.42	0.00

Increased Tenderness in Pounds of WBSF

Genetic Solutions, GeneNOTE 4

Calpain is the second DNA marker released to evaluate tenderness. Much of the research on Calpain has been produced at Meat Animal Research Center (MARC) and as such this information is in the public domain, meaning DNA tests can be developed based on this research by any commercial company. On-going research has identified several SNPs for Calpain. The best way to think of these SNPs is as pointers to the actual gene, genetic road signs pointing to the ultimate destination. For example, in Kansas City you would see a sign on I-70 indicating Denver as a destination in 602 miles heading west. A similar sign in Salt Lake City would put you in Denver in 533 miles heading east. Both starting points (SNPs) get you to the same destination (Calpain), but each trip takes a different amount of time (effect).

In the case of Calpain there are two SNPs that have been shown to produce consistent correlations to tenderness as measured by Warner-Bratzler Shear Force. The first SNP, 316, was brought to the market late in 2003. More recently a new SNP, 4751, has also been released (marketed by Bovigen as T3). While the combination of these two SNPs has an increased effect on Tenderness than either SNP independently, the combined effect on Tenderness is not twice the value. Because of this fact we must understand the power of the combinations rather than simply adding them together. Below in Table C are the results that were reported by MARC on these two SNPs in combination *(White et al., J. Anim. Sci. 83:2001-2008).* As discussed in Wayne Vanderwert's editorial, the addition of this new SNP is one more reason why it is important to understand the genotyes, combinations and their effects.

Table C.

Calpain		Effect
316	4751	lbs.
2 (CC)	2(CC)	-1.23
1(CG)	2(CC)	-0.84
0(GG)	2(CC)	-0.68
1(CG)	1(CT)	-0.46
0(GG)	1(CT)	-0.13
0(GG)	0(TT)	0.00

Source: MARC, White et al., 2005

Additional research has shown that Calpain and Calpastatin are independent of each other and their effects on Tenderness

Frequencies of DNA Markers

Bovigen provided the statistics shown at right, on Gelbvieh and Balancer® cattle tested to date. These statistics represent approximately 500 plus Gelbvieh tests and 150 plus Balancer tests. While it gives us a starting point, what may be the true frequencies of these markers in the total Gelbvieh and Balancer population has yet to be determined. Only testing of a significantly greater percentage of our genetic base will paint the true picture of these frequencies.

	CAST			$CALP_{316}$			$CALP_{4751}$		
	2(AA)	1(GA)	0(AA)	2(CC)	1(CG)	0 (GG)	2(CC)	1(CT)	0(TT)
Gelbvieh	59%	35%	5%	0%	10%	90%	6%	44%	50%
Balancer	67%	33%	0%	0%	37%	63%	18%	71%	12%
British	73%	24%	3%	16%	44%	40%	53%	38%	8%
Continental	73%	24%	2%	2%	19%	80%	11%	46%	43%
Brahman Infl.	60%	35%	5%	5%	30%	65%	12%	34%	54%

(Source: Bovigen animals tested through December 2005.)

are additive, so we can predict the effect of a genotype by combining the two effects together. However, because in total we are looking at three markers for two different genes there are 27 possible combinations and we find that similar star totals (see 4 star example below) do not all produce and equal effect.

Same Number of Stars, Different Effect

Tenderness Genotypes			Individual Marker Effects		Additive Marker Effects	Total Stars
CAST	$CALP_{316}$	$CALP_{4751}$	CAST	$CALP_{316, 4751}$		
0 (GG)	2(CC)	2(CC)	0 lbs	-1.23 lbs	-1.23 lbs	4
2(AA)	0(GG)	2(TT)	-.81 lbs	-.68 lbs	-1.49 lbs	4
2(AA)	1(CG)	1(CT)	-.81 lbs	-.46 lbs	-1.27 lbs	4

Changing the Next Generation

In order to increase the Tenderness of the beef produced by Gelbvieh-influenced cattle, we need to increase the percentage of cattle that carry these markers in the favorable form (2s). Using a traditional Punnett square illustrates the outcomes of various planned matings.

Using CAST genotypes for example:

Breeding a CAST 2 (AA) bull to a CAST 1 (AG) cow produces the following progeny types

		Cow A	Cow G
Sire	A	AA	AG
Sire	A	AA	AG

Progeny = 50% AA (CAST 2)
50% AG (CAST 1)

Breeding a CAST 1 (AG) bull to a CAST 1 (AG) cow produces the following progeny types

		Cow A	Cow G
Sire	A	AA	AG
Sire	G	AG	GG

Progeny = 25% AA (CAST 2)
50% AG (CAST 1)
25% GG (CAST 0)

The positive news is that many of the genes needed to improve tenderness in the Gelbvieh breed are present in the population. Increased testing will locate even more animals that have the genes necessary to effect change in the breed. DNA testing is just one piece of the breeding decision puzzle. EPDs and phenotype, along with traits not measured by EPDs need to be considered when making breeding decisions. ■

Top 25 Gelbvieh A.I. Sires DNA Marker Results

Rank	Registered Name	Quality Grade TG5	Quality Grade M2	Tenderness CAST	Tenderness Calp 316	Tenderness Calp 4751
1	SLC Freedom 178F ET	0	1	2	0	1
		CC	GA	AA	GG	CT
2	XXB Drew 565K	0	0	2	0	0
		CC	GG	AA	GG	TT
3	JRI Pld Free Agent 125J3	0	0	2	0	1
		CC	GG	AA	GG	CT
4	RTC Atlas 712G	0	0	1	0	1
		CC	GG	GA	GG	CT
5	EGL Fosters L017 ET	0	0	2	0	2
		CC	GG	AA	GG	CC
6	ELK CK Bronco 411G	0	0	2	0	0
		CC	GG	AA	GG	TT
7	KCF Bennett Landmark J377	1	0	1	0	0
		CT	GG	GA	GG	TT
8	KIT Tabasco J26 ET	0	0	1	0	1
		CC	GG	GA	GG	CT
9	SPUR Beretta 703G	0	0	1	0	1
		CC	GG	GA	GG	CT
10	JCGR Bar GT Mach One 54 L	0	1	1	0	1
		CC	GA	GA	GG	CT
11	FHG VVFG Flying H Exclusive	0	0	1	0	1
		CC	GG	GA	GG	CT
	RUP Rupple Gigolo 991L ET	2	0	2	0	0
		TT	GG	AA	GG	TT
12	BTI Red Alert 2077K	0	0	2	0	1
		CC	GG	AA	GG	CT
	FHG Flying H Extra 150D	0	0	2	0	0
		CC	GG	AA	GG	TT
	EGL Guido K051 ET	0	1	1	0	1
		CC	GA	GA	GG	CT
13	JRI Extra Exposure 285L71 ET	0	0	2	RP	0
		CC	GG	AA		TT
14	MRCO New Direction 905	0	1	2	0	0
		CC	GA	AA	GG	TT
	SPUR Kings Ransome 901J	0	1	1	RP	1
		CC	GA	GA		CT
15	KCF Bennett Ideal G182	0	0	1	0	0
		CC	GG	GA	GG	TT
16	MLLC M/L Encore	1	0	1	0	1
		CT	GG	GA	GG	CT
17	JBOB 2279J ET	0	0	1	0	0
		CC	GG	GA	GG	TT
	VRT Lazy TV Beethoven K278	0	0	2	1	2
		CC	GG	AA	CG	CC
18	JBOB Carolina Fortune 2564 J ET	0	1	2	0	0
		CC	GA	AA	GG	TT
19	RAG Mr. Extra Wonderful ET	0	0	2	0	0
		CC	GG	AA	GG	TT
20	JBOB Carolina CPR	0	1	2	0	0
		CC	GA	AA	GG	TT

**Rank refers to number of calves recorded in 2004.*