Beef Cattle Evaluation

Commercial Genetic Test Validation

IGENITY Tenderness:

- <u>Summary</u>
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Summary:

Igenity profile Tenderness is a DNA genetic marker panel test comprised of three markers (UoGCAST1, Calpain 4751 and Calpain 316). An increase in "tenderness" is associated with substituting a "C" allele at calpastatin (UoGCAST1) and a "C" allele at both µ-calpain loci (Calpain 4751 and Calpain 316). The following table shows the decrease in "toughness" (Warner-Bratzler Shear Force, lb) for each of the possible genotypes contrasted to the least tender genotype (i.e. UoG-Cast1 "GG", Capn4751 "TT", Capn316 "GG") calculated from a combined analysis of 1209 cattle from four sample populations (Brangus, Charolais x Angus cross, Red Angus and Brahman) used in the validation study.

Genotype)	Estimato		Number					
UoG- Cast1	Calpain 316	Calpain 4751	(lbs.)	Standard Error	Obs.	%				
		CC	-2.3	0.4	18	1.5				
	СС	CT	-1.1	0.6	8	0.7				
		TT	0.1	1.0	0	0.0				
		CC	-1.9	0.3	60	5.0				
СС	CG	CT	-1.5	0.3	123	10.2				
		TT	-0.4	0.5	9	0.7				
		CC	-1.6	0.3	60	2.7				
	GG	СТ	-1.2	0.3	181	15.0				
		TT	-0.8	0.2	212	17.5				
	CC	CC	-1.9	0.3	9	0.7				
		CT	-0.7	0.5	1	0.1				
		TT	0.5	1.0	0	0.0				
		CC	-1.5	0.2	42	3.5				
CG	CG	CG	CG	CG	CG	СТ	-1.1	0.2	74	6.1
		TT	0.1	0.5	4	0.3				
		CC	-1.2	0.3	23	1.9				
	GG	CT	-0.8	0.2	91	7.5				
		TT	-0.4	0.1	204	16.9				
GG		CC	-1.4	0.3	2	0.2				
	CC	CT	-0.2	0.5	1	0.1				
		TT	1.0	1.0	0	0.0				
		CC	-1.1	0.2	7	0.6				
	CG	СТ	-0.7	0.1	9	0.7				
		TT	0.5	0.5	0	0.0				
	GG	CC	-0.8	0.3	5	0.4				
		СТ	-0.4	0.1	30	2.5				
		TT	0		63	5.2				

The yellow shaded genotypes involve the rare "T-C" haplotype. The low number of animals with this genotype in the data set made it difficult to accurately estimate the size of its effect.

The Calpastatin marker (UogCAST1) and the Calpain haplotypes based on CAPN4751 and CAPN316) were each highly significant. The combination of all three even more so. Each calpastatin "C" was associated with a decrease of 0.4 lb of Warner-Bratzler Shear Force, and substituting the Calpain 4751 "C" - 316 "C" haplotype for the Calpain 4751 "T" - 316 "G" was associated with a decrease of 0.7 lb of Warner-Bratzler Shear Force. Among genotypes with sufficient information there was a 2.3 lb. difference in WBSF between the best (homozygous C at all three markers) and the worst GG-TT-GG (UoGCAST1-CAPN4751-CAPN316). Breeders should not expect gains this large because no herd will consist 100% of the 'least tender' genotype.

Test Claims:

Igenity profile Tenderness is a DNA genetic marker panel test offered by Igenity. Increase in "tenderness" is associated with favorable alleles of a marker panel that includes Calpain 4751 (i.e. a "C" allele at the 4751 SNP of calpain), Calpain 316 (i.e. a "C" allele at the 316 SNP of calpain), and UofG-CAST1 (i.e. a "C" allele at the UofGCAST1).

Test Details:

Polymorphisms analyzed

- CAPN1 316 = SNP "316" in µ -calpain (micromolar calcium activated neutral protease 1).
- CAPN1 4751 = SNP "4751" in µ -calpain (micromolar calcium activated neutral protease 1).
- UofG-CAST1 = SNP in calpastatin (calpain inhibitor). Note this is a different SNP from CAST-T1 (GeneSTAR® Tenderness).

Sample Populations:

Cattle Used for Validation

- 1. Brahman Sired ARS, Brooksville cattle (344 animals) * Brahman sires, Brahman dams
- 2. Brangus Sired CMP* cattle (219 animals)
 * Brangus sires, primarily Brangus and some Brangus cross dams
- 3. Charolais Sired CMP* cattle (435 animals) * Charolais sires, Black Angus dams
- 4. Red Angus Sired CMP* cattle (307 animals) * Red Angus sires, mostly Red Angus dams, some crossbred
- 5. Black Angus cattle (394 animals)
 - * Angus sires, Black Angus dams

* CMP = carcass merit project; influential sires in their breed in the 1990s were utilized ("legacy bulls")

Allele Frequencies*:

Deference Denulation		CA	LPAIN 4	751	CALPAIN 316			UoG-CAST1		
Reference Population		CC	СТ	TT	CC	GC	GG	GG	GC	CC
	Genotype No.	426	724	556	113	561	1042	175	604	896
Combined	Genotype %	25	42	33	7	33	61	14	48	71
Compined	Allele %	46%		54%	23%		77%	28%		9448%
	Total No.		1706			1716			1268	
	Genotype No.	64	111	44	5	67	145	10	65	128
Brongue	Genotype %	29	51	20	2	31	67	5	32	63
brangus	Allele %	55%		45%	18%		82%	21%		79%
	Total No.		219			217			203	
	Genotype No.	82	234	119	19	163	253	20	137	255
Charalaia y Angua	Genotype %	19	54	27	4	37	58	5	33	62
Charolais X Angus	Allele %	46%		54%	23%		77%	26%		74%
	Total No.		307			307			305	
Red Angus	Genotype No.	63	165	79	15	110	182	23	111	171
	Genotype %	21	54	26	5	36	59	8	36	56
			1				1	Ĩ		

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	Allele %	47%		53%	23%		77%	26%		74%
	Total No.		307			307				
	Genotype No.	5	45	280		10	333	113	163	68
Brohmon	Genotype %	2	14	85		3	97	33	47	20
Diamian	Allele %	8%		92%	1%		99%	57%		43%
	Total No.		330			343			344	
	Genotype No.	212	169	34	74	211	129	9	128	274
Plack Angua	Genotype %	51	41	8	18	51	31	2	31	67
Black Aligus	Allele %	71%		29%	43%		57%	18%		82%
	Total No.		415			414			411	

* These are the frequencies in the data analyzed and are not necessarily reflective of any purebred population.

IGENITY profile Tenderness Results :

Α.

Reference	T	Number	Contrast						
Population	Iran.	Head	Gene(s)	DF	F	Р			
			ITG* (UolG-Casti & CAPN1)	4	10.6	1.9E-08			
Combined		1209	VolG-Cast1*	1	14.1	1.8E-04			
			CAPH1 (4751 & 316 haplotype)*	3	93	4.7E-06			
			ITG** (UofG-Cast1 & CAPN1)	4	1.7	0.16			
Brangus		181	UofG-Cast1*	1	0.04	0.84			
			CAPN1 (4751 & 316 haplotype)*	3	2.2	0.09			
Charolais	Manage Destator		ITG** (UofG-Cast1 & CAPN1)	4	8.0	3.1E-06			
x	Wallies-Dialzes Choor Force (b)	400	UofG-Cast1*	1	8.2	4.4E-03			
Angus	sileal fuice (iii)		CAPN1 (4751 & 316 haplotype)*	3	8.2	2.8E-05			
			ITG** (UofG-Cast1 & CAPN1)	4	2.9	0.02			
Red Angus		310	UofG-Cast1*	1	1.2	0.27			
			CAPN1 (4751 & 316 haplotype)*	3	3.1	0.03			
			ITG** (UofG-Cast1 & CAPN1)	3	4.3	0.01			
Brahman		318	UofG-Cast1*	1	5.8	0.02			
			CAPN1 (4751 & 316 haplotype)*	2	3.7	0.03			

	Mission Destator		ITG** (UofG-Cast1 & CAPN1)	4	8.2	0.00
Angus***	Shoor Force (b)	318	UofG-Cast1*	1	4.4	0.04
_			CAPN1 (4751 & 316 haplotype)*	3	9.7	0.00

*** The Angus CMP population was analyzed at a later date than the other sample populations and so this data is not included in the combined analysis.

** ITG = Igenity profile Tenderness combined marker panel = total number of favorable UofG-Cast1 alleles & CAPN1 haplotypes.

*effect of UofG-Cast1 and CAPN1 haplotype estimated separately; CAPN1 haplotype has a larger effect than UofG-Cast1.

* Genotype effects constructed from effects estimated in the haplotype analysis (Table B)

В.	Combined Three-marker Genotype Effects (contrasted to UoG-Cast	"GG"	, Capn316 "G0	G", Capn4751	"TT")	, Standard Erro	ors
an	d Frequencies* in Reference Samples						

Genotype			Estimato		Number	
UoG- Cast1	Calpain 316	Calpain 4751	(lbs.) Standard Error		Obs.	%
CC		CC	-2.3	0.4	18	1.5
	CC	СТ	-1.1	0.6	8	0.7
		TT	0.1	1.0	0	0.0
		CC	-1.9	0.3	60	5.0
	CG	СТ	-1.5	0.3	123	10.2
		TT	-0.4	0.5	9	0.7
	GG	CC	-1.6	0.3	60	2.7
			-1.2	0.3	181	15.0

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		TT	-0.8	0.2	212	17.5
		CC	-1.9	0.3	9	0.7
	CC	СТ	-0.7	0.5	1	0.1
		TT	0.5	1.0	0	0.0
		CC	-1.5	0.2	42	3.5
CG	CG	СТ	-1.1	0.2	74	6.1
		TT	0.1	0.5	4	0.3
		CC	-1.2	0.3	23	1.9
	GG	СТ	-0.8	0.2	91	7.5
		TT	-0.4	0.1	204	16.9
	СС	CC	-1.4	0.3	2	0.2
		СТ	-0.2	0.5	1	0.1
		TT	1.0	1.0	0	0.0
		CC	-1.1	0.2	7	0.6
GG	CG	СТ	-0.7	0.1	9	0.7
		TT	0.5	0.5	0	0.0
		CC	-0.8	0.3	5	0.4
	GG	СТ	-0.4	0.1	30	2.5
		TT	0		63	5.2

The yellow shaded genotypes involve the rare "T-C" haplotype. The low number of animals with this genotype in the data set made it difficult to accurately estimate the size of its effect.

C. Effect of One Copy of a UoGCAST1 Allele or CAPN1 Haplotype on the Target Trait

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Population Trait Head Gene Haplotype Frequency Effect Error Branzler Branzler GG AST C 8.72 9.02 9.11 Combined Shear 1289 CAPI#1 C.C 8.16 9.12 8.15 Force 316 C-T 0.01 0.48 0.60 Force 316 C-T 0.01 0.48 0.60 Force 4751 G-T 8.61 9 - Branzgus Force 316 C-T 0.01 0.48 0.00 Shear 181 CAPI#1 C.C 0.17 0.72 0.28 Force 316 C-T 0.00 -0.23 1.78 Force 316 C-T 0.01 -0.23 1.78 Force 316 C-T 0.45 0 - Shear 449 G-T 0.50 0.40 - Argus Shear			No.		Allele/	Sample	E stimuted	Standard
Varmer- Brazier UdGCAST C 8.72 4.42 6.11 Cambined Shear 1289 CAPM1 C.C 8.16 8.72 6.15 Force Shear 1289 CAPM1 C.C 8.16 6.72 6.15 Force Shear 1289 6.6 0.22 3.00 0.50 Brazier 4751 6 0.22 3.00 0.26 0.26 Brazier 00GCAST C 0.79 0.05 0.26 Brazier 100GCAST C 0.79 0.05 0.26 Force 316 C-T 0.00 -0.23 1.78 Force 316 C-T 0.00 -0.23 1.78 Brazier 48 G-C 0.37 0.16 - Angus Shear 480 C-T 0.03 0.55 0.41 Angus Shear 316 C-T 0.03 0.55 0.41 Force	Population	Trait	Head	Gene	Haplotype	Frequency	Effect	Error
Cambined Biratcler Shear 1289 128 CAPN 1 C.C 8.18 4.72 0.15 Force (Tenderness) 6 6.7 0.01 0.48 0.50 Karner- Brangus Warner- Bintcler UGCAST C 8.28 4.72 4.13 Karner- Brangus Shear 181 CAPN 1 C.C 0.21 0.00 - Brangus Shear 181 CAPN 1 C.C 0.17 -0.72 0.28 Brancler Bintcler 106 C-T 0.00 - - 0.00 - - 0.23 1.78 0.23 1.78 0.23 1.78 0.23 1.78 0.23 1.78 0.21 0 - - 0.23 1.78 0.16 0.14 0.17 0.23 1.78 0.16 0.14 0.17 0.23 1.78 0.16 0.17 0.16 0.17 0.16 0.17 0.16 0.17 0.16 0.17 0.16 0.17 0.16 </th <th rowspan="5">Cambined</th> <th>Warner-</th> <th></th> <th>UoGCAST</th> <th>С</th> <th>0.72</th> <th>-9.42</th> <th>0.11</th>	Cambined	Warner-		UoGCAST	С	0.72	-9.42	0.11
Combined Force (Tenderness) Shear (Tenderness) 1205 316 C.C 4.16 4.72 0.45 (Tenderness) (Tenderness) 316 C.T 0.01 0.48 0.50 4751 G-T 0.61 0 0.50 0.50 Brangus Branzter (Tenderness) UdGCAST C 0.73 0.05 0.26 Brangus Shear 181 CAPN1 C-C 0.17 -0.72 0.28 Force (Tenderness) 316 C-T 0.00 -0.23 1.78 Branzter (Tenderness) 4751 G-T 0.00 -0.23 1.78 Marner- (Tenderness) UdGCAST C 0.37 -0.12 0.23 X Force Tence 316 C-T 0.03 0.55 0.16 X Force 316 C-T 0.03 0.55 0.16 X Force 316 C-T 0.03 0.55 0.19 Red Angus Shear 310 CAPN1		Bratzler			6	8.28	•	-
Force (fenderness) 316 C-T 0.01 0.48 0.50 4 6-C 0.22 0.40 0.13 Argus Bratzler 0 0.79 0.05 0.26 Bratzler 0 0.79 -0.05 0.26 0.26 Bratzler 181 CAPN1 C-C 0.17 -0.72 0.28 Force 316 C-T 0.00 -0.23 1.78 G 0.21 0.00 -0.23 1.78 Force 316 C-T 0.05 0.23 Force 316 C-T 0.07 -0.12 0.23 Karnolais Bratzler 6 0.21 0 - Shear 400 CAPN1 C-C 0.20 -0.76 0.16 X Force 316 C-T 0.03 0.55 0.41 Charnolais Force 316 C-T 0.03 0.55 0.16 X Forc		Shear	1289	CAPH1	C-C	8.16	-0.72	0.15
Karner- Brangus Warner- Bratzler Warner- Bratzler UdGCAST C 0.73 0.05 0.26 Brangus Shear 181 CAPN1 C.C 0.01 0.00 Brangus Shear 181 CAPN1 C.C 0.01 -0.72 0.28 Grademessis Shear 181 CAPN1 C.C 0.00 0.23 1.78 Grademessis Grademessis 4751 G-T 0.45 0 Karner- Charolais Bratzler UdGCAST C 0.73 -0.40 0.14 Charolais Force (Tendemessi Marner- Shear UdGCAST C 0.20 -0.76 0.16 X Force (Tendemessi 316 C.T 0.02 Red Angus Shear 340 CAPN1 C.C 0.23 -0.55 0.19 Red Angus Shear 346 G-T 0.01 0.86 0.85 0.17		Force		316	C-T	0.01	0.48	0.50
Warmer- Brangus Warmer- Shear UGGCAST C. 0.05 0.26 Brangus Shear 181 CAPN1 C.C 0.17 -0.02 0.23 Brangus Shear 181 CAPN1 C.C 0.17 -0.72 0.23 Force 316 C.T 0.00 0.23 1.78 (Earderness) E G-C 0.37 -0.12 0.23 Bratzler Shear 4400 CAPN1 C.C 0.79 -0.40 0.14 Charolais Shear 4400 CAPN1 C.C 0.26 0 Angus Force (Tenderness) 4400 CAPN1 C.C 0.26 0.11 Shear 316 C.T 0.03 0.55 0.41 Angus Shear 310 C.T 0.01 0.65 0.41 Force G G.C 0.26 0 0.7 Bratzler Shear 310 </th <th>(Tenderness)</th> <th></th> <th>E .</th> <th>6-C</th> <th>8.22</th> <th>-9.49</th> <th>0.13</th>		(Tenderness)		E .	6-C	8.22	-9.49	0.13
Warner- Branzers Warner- Shear Uo6CAST C 0.79 -0.05 0.26 Branzers Shear 18 CAPW1 C.C 0.00 023 0.26 Force (Tendemess) 316 C.T 0.00 -0.23 1.78 Argus Bratzler (Tendemess) 4751 G-T 0.05 0.17 0.23 Charolais x Bratzler (Tendemess) 4751 G-T 0.45 0 Charolaiss Bratzler Shear 440 C.C 0.79 -0.40 0.14 Charolaiss Force (Tendemess) 16 C.T 0.03 0.55 0.16 Argus Force (Tendemess) 16 C.T 0.03 0.55 0.16 Bratzler Red Argus Shear 316 C.T 0.01 0.86 0.85 Bratzler Red Argus Shear 316 C.T 0.01 0.86 0.85 Gree (Tendemess) Shear 316 C.T 0.01 0.56 0.56				4751	6-T	0.61	•	-
Brangus Branzier Shear 181 Force (Tendemess) CAPN1 C.C 0.17 0.72 0.28 Brangus Force (Tendemess) 316 C.T 0.00 -0.23 1.78 Branz 6 C.T 0.00 -0.23 1.78 Marner- Brazzer 8 G.C 0.37 0.12 0.23 Marner- Brazzer Brazzer 44751 G.T 0.45 0 - Charolais Xangus Shear 440 CAPN1 C.C 0.20 -0.76 0.16 Xangus Force (Tendemess) 316 C.T 0.03 0.55 0.41 Angus Force (Tendemess) 4751 G.C 0.26 . Bradzler Uo6CAST C 0.74 0.19 0.17 Bradzler G.C 0.74 0.19 0.17 Bradzler G.C 0.23 -0.55 0.19 Bradzler J16 C.T 0.01 . .		Warner-		UoGCAST	C	0.79	-0.05	0.26
Brangus Shear Force (Tenderness) 181 Force (Tenderness) CAPN1 CC 0.17 -0.72 0.28 316 C.T 0.00 -0.23 1.78 (Tenderness) ã G-C 0.37 -0.12 0.23 A751 G-T 0.45 0 . Argus Bratzler Shear 400 CAPN1 CC 0.20 -0.76 0.14 Angus Bratzler (Tenderness) 400 CAPN1 CC 0.20 -0.76 0.16 x Shear 400 CAPN1 CC 0.26 -0.37 0.16 x G-C 0.26 -0.37 0.16 - - - x G-C 0.26 0.21 0 - - - Bratzler Bratzler UG6CAST C 0.74 -0.19 0.17 Bratzler Shear 316 CT 0.01 0.86 0.85 Bratzler Shear		Bratzler			G	0.21	0.00	-
binaryos Force (Tenderness) 316 C-T 0.00 -0.23 1.78 (Tenderness) 4 6 6.2 0.37 -0.12 0.23 A751 G-T 0.45 0 . 0.23 0.14 Charolais Bratzler 0.66CAST C 0.79 -0.40 0.14 Shear 400 CAPN1 C-C 0.20 -0.76 0.16 Angus Force 316 C-T 0.03 0.55 0.41 Charolais Shear 400 24 0 . . Angus Force 316 C-T 0.03 0.55 0.41 Charolais Shear 310 CAPN1 C-C 0.23 -0.55 0.17 Red Angus Shear 310 CAPN1 C-C 0.23 -0.55 0.17 Force G G.25 0.24 0.20 - - Bratzler Shear 318 </th <th>B</th> <th>Shear</th> <th>181</th> <th>CAPN1</th> <th>C-C</th> <th>0.17</th> <th>-0.72</th> <th>0.28</th>	B	Shear	181	CAPN1	C-C	0.17	-0.72	0.28
(Tendemess) 6 6-C 0.37 -0.12 0.23 4751 6-T 0.45 0 . . A751 6-T 0.45 0 . . Charolais X Bratzler 0.21 0 . . Angus Force 316 C-T 0.03 0.55 0.41 Force 316 C-T 0.03 0.55 0.41 . Angus Force 316 C-T 0.03 0.55 0.41 Karner- Ud6CAST G-C 0.26 0 . . Red Angus Shear 310 CAPN1 C-C 0.23 -0.55 0.19 Force G 0.26 0 Red Angus Shear 316 C-T 0.01 0.86 0.85 (Tendemess) E E G-C 0.23 -0.25 0.24	n nigus	Force		316	C-T	0.00	-0.23	1.78
Marmer- Bratzler Warmer- Bratzler UdGCAST C 0.45 0 Angus Shear 400 CAPN1 C.C 0.20 -0.76 0.16 X Shear 400 CAPN1 C.C 0.20 -0.76 0.16 Angus Force 316 C.T 0.03 0.55 0.41 Red Angus Warmer- UdGCAST C 0.26 -0.37 0.16 Red Angus Shear 310 C.T 0.03 0.55 0.11 Red Angus Shear 310 C.T 0.07 0.19 0.17 Bratzler UdGCAST C 0.74 -0.19 0.17 Bratzler 316 C.T 0.01 0.86 0.85 Grandermess) E G-C 0.25 0.19 0.26 Bratzler 316 C.T 0.01 0.86 0.85 Grandermess) E G 0.57 0 </th <th></th> <th>(Tenderness)</th> <th></th> <th>2</th> <th>G-C</th> <th>0.37</th> <th>-0.12</th> <th>0.23</th>		(Tenderness)		2	G-C	0.37	-0.12	0.23
Warmer- Bratzler X Angus Warmer- Shear UoGCAST C 0.79 -0.40 0.14 X Shear 400 CAPN1 CC 0.20 -0.76 0.16 X Force (Tenderness) 316 C-T 0.03 0.55 0.41 K 6-C 0.26 -0.37 0.16 0 - K 6-C 0.26 -0.37 0.16 0 - K 6-C 0.26 -0.37 0.16 0 - K G-T 0.51 0 - - 0.17 Bratzler UoGCAST C 0.74 -0.19 0.17 Bratzler 316 C-T 0.01 0.86 0.85 Force 6 C.27 0.23 -0.55 0.91 Bratzler 316 C-T 0.01 0.86 0.85 Bratzler 316 C-T 0 - - Bratzler 316				4751	G-T	0.45	0	-
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		Warner-		UdGCAST	С	0.79	-0.40	0.14
Charolatis Angus Shear Force (Tendemess) 400 Force (Tendemess) CAPN1 C-C 0.20 -0.76 0.16 Angus Force (Tendemess) 316 C-T 0.03 0.55 0.41 Angus Force (Tendemess) 6 G-C 0.26 -0.37 0.16 Marner- Bratzier 4751 G-T 0.51 0 . Shear 310 CAPN1 C-C 0.23 -0.55 0.19 Shear 310 CAPN1 C-C 0.23 -0.55 0.19 Force 316 C-T 0.01 0.86 0.85 (Tendemess) 4 G-C 0.25 -0.24 0.20 Force 316 C-T 0.01 0.86 0.85 Bratzier G G-T 0.51 0 . Bratzier 316 C-T 0.02 -1.36 0.56 Argus*** Shear 318 CAPN1 C-C 0.02 0 <	CL L=-	Bratzler			G	0.21	0	-
Angus Force (Tendemess) 316 C-T 0.03 0.55 0.41 Angus (Tendemess) & G-C 0.26 -0.37 0.16 4751 G-T 0.51 0 . . . Marmer- Bratzler UoGCAST C 0.74 -0.19 0.17 Bratzler G 0.26 0 Shear 316 C-T 0.01 0.86 0.85 . Force 316 C-T 0.01 0.86 0.85 . (Tendemess) & G-T 0.01 0.86 0.85 Bratzler G G-T 0.01 0.86 0.85 Bratzler G G-T 0.51 0 . . Bratzler 316 C-T 0 . . . (Tendermess) & G G-C 0.02 1.19 . Bratzler		Shear	400	CAPN1	C-C	0.20	-0.76	0.16
Migus (Tendemess) & 6-C 0.26 -0.37 0.16 4751 G-T 0.51 0 Warner- Bratzler Warner- Bratzler Uo6CAST C 0.74 -0.19 0.17 Bratzler G 0.26 0 .		Force		316	C-T	0.03	0.55	0.41
Marmer- Bratzler 4751 $G-T$ 0.51 0 . Bratzler Bratzler G 0.74 0.19 0.17 Shear 310 CAPN1 C-C 0.26 0 . Force 316 C.T 0.01 0.86 0.85 (Tendemess) 4751 G-T 0.01 0.86 0.85 Bratzler 4751 G-T 0.01 0.86 0.85 Bratzler 4751 G-T 0.51 0 . Bratzler UoGCAST C 0.43 0.73 0.026 Bratzler G $CAPN1$ C-C 0.02 4127 1.19 Bratzler 316 C-T 0 $ -$ Bratzler 316 C-T 0.07 -1.36 0.56 G G-T 0.92 0 $ -$ Bratzler 394 GAST	Angus	(Tenderness)		2	G-C	0.26	-0.37	0.16
Warner- Bratzler UoGCAST C 0.74 -0.19 0.17 Shear 310 CAPN1 C-C 0.26 0 . Force 316 C-T 0.01 0.86 0.85 (Tenderness) 6 G-C 0.25 -0.24 0.20 4751 G-T 0.01 0.86 0.85 Bratzler 4751 G-T 0.51 0 . Bratzler UoGCAST C 0.43 -0.73 0.30 Bratzler G 0.57 0 . . Bratzler G 0.57 0 . . Bratzler 316 C-T 0.02 4.27 1.19 Force 316 C-T 0 . . (Tenderness) 4751 G-T 0.92 0 . Margues*** Shear 394 CAPN1 C-C 0.43 -0.56 . force				4751	G-T	0.51	0	-
$\begin{tabular}{ c c c c } \hline $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $		Warner-	310	UoGCAST	С	0.74	-0.19	0.17
Red Angus Shear Force (Tendemess) 310 CAPN1 C-C 0.23 -0.55 0.19 (Tendemess) 316 C-T 0.01 0.86 0.85 (Tendemess) E G-C 0.25 -0.24 0.20 4751 G-T 0.51 0 . Bratzler UoGCAST C 0.43 -0.73 0.30 Bratzler G 0.57 0 . . Shear 318 CAPN1 C-C 0.02 -1.27 1.19 Force 316 C-T 0 (Tendemess) E G-C 0.07 -1.36 0.56 . (Tendemess) E G-T 0.92 0 . . Angus*** Shear 394 CAPN1 C-C 0.43 0.56 0.13 Force G16 C-T 0 		Bratzler			G	0.26	0	-
Kein Angus Force (Tenderness) 316 C-T 0.01 0.86 0.85 (Tenderness) & & G-C 0.25 -0.24 0.20 4751 G-T 0.51 0 . . . Argus Warner- Brahman UoSCAST C 0.43 -0.73 0.30 Brahman Shear 318 CAPN1 C-C 0.02 -1.27 1.19 Brahman Shear 318 CAPN1 C-C 0.02 -1.27 1.19 Force 316 C-T 0 - - - - (Tenderness) & G-C 0.07 -1.36 0.56 - Angus*** Marmer- Bratzler UoSCAST C 0.82 -0.30 0.14 Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 (Tenderness) & G C-T 0 - -	D-44	Shear		CAPN1	C-C	0.23	-0.55	0.19
(Tendemess) & G-C 0.25 -0.24 0.20 4751 G-T 0.51 0 . Warner- Brahman Warner- Bratzler Ud6CAST C 0.43 -0.73 0.30 Brahman Shear 318 CAPN1 C-C 0.02 -1.27 1.19 Brahman Shear 318 CAPN1 C-C 0.02 -1.27 1.19 Brahman Shear 318 CAPN1 C-C 0.02 -1.27 1.19 Force 316 C-T 0 -	Kea Aigus	Force		316	C-T	0.01	0.86	0.85
Marmer- Brahman Warmer- Bratzler UdGCAST C 0.413 -0.73 0.30 Brahman Shear 318 CAPN1 C-C 0.02 -1.27 1.19 Brahman Shear 318 CAPN1 C-C 0.02 -1.27 1.19 Force 316 C-T 0 - - - - (Tenderness) & G-C 0.07 -1.36 0.56 - - Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 Force 316 C-T 0 - - - - Marmer- Bratzler UoGCAST C 0.82 -0.30 0.14 - G 0.18 0 - - - - - - Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 Force 316 C-T 0 -		(Tenderness)		E	G-C	0.25	-0.24	0.20
Warmer- Bratzler Ud6CAST C 0.43 -0.73 0.30 Bratzler G 0.57 0 . Shear 318 CAPN1 C-C 0.02 -1.27 1.19 Force 316 C-T 0 -				4751	G-T	0.51	0	-
Bratzler G 0.57 0 . Shear 318 CAPN1 C-C 0.02 1.27 1.19 Force 316 C-T 0 - - - (Tenderness) 6 G-C 0.07 -1.36 0.56 4751 G-T 0.92 0 - Hamer- UoGCAST C 0.82 -0.30 0.14 G 0.18 0 - - - - Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 Force 316 C-T 0 - - - - Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 Force 316 C-T 0 - - - (Tenderness) 6 G-C 0.28 0.03 0.56		Warner-		T2A300U	C	0.43	-0.73	0.30
Brahman Shear 318 CAPN1 C-C 0.02 -1.27 1.19 Force (Tendemess) 316 C-T 0 0 0 0 0 (Tendemess)		Bratzler			G	0.57	0	-
Force (Tendemess) 316 C-T 0 (Tendemess) & G-C 0.07 -1.36 0.56 4751 G-T 0.92 0 - Warmer- Bratzler UoGCAST C 0.82 -0.30 0.14 G 0.18 0 - - - - Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 Force (Tendemess) 316 C-T 0 - - -	Restances	Shear	318	CAPN1	C-C	0.02	-1.27	1.19
(Tendemess) & G-C 0.07 -1.36 0.56 4751 G-T 0.92 0 . Warner- Bratzler UoGCAST C 0.82 -0.30 0.14 Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 Force (Tendemess) 316 C-T 0 - - -		Force		316	C-T	0		
4751 G-T 0.92 0 . Warner- Bratzler UoGCAST C 0.82 -0.30 0.14 Bratzler G 0.18 0 . . Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 Force (Tendemess) 316 C-T 0 . . .		(Tenderness)		£	G-C	0.07	-1.36	0.56
Warner- Bratzler Uo6CAST C 0.82 -0.30 0.14 Bratzler G 0.18 0 . Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 Force 316 C-T 0 -				4751	G-T	0.92	0	-
Warner- Bratzler UoGCAST C 0.82 -0.30 0.14 Bratzler G 0.18 0 . . Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 Force 316 C-T 0 -								
Bratzler G 0.18 0 . Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 Force 316 C-T 0 <th0< th=""><th></th><th>Warner-</th><th></th><th>U oG CA ST</th><th>С</th><th>0.82</th><th>-0.30</th><th>0.14</th></th0<>		Warner-		U oG CA ST	С	0.82	-0.30	0.14
Angus*** Shear 394 CAPN1 C-C 0.43 -0.56 0.13 Force 316 C-T 0		Bratzler			G	0.18	0	-
Force 316 C-T 0 (Tendemess) & G-C 0.28 0.03 0.56 4751 G-T 0.28 0 -	Encount#	Shear	394	CAPIL1	C-C	0.43	-0.56	0.13
(Tendemess) & G-C 0.28 0.03 0.56 4751 G-T 0.28 0	AUGUS-	Force		316	C-T	0		
4751 G-T 0.28 0		(Tenderness)		- -	G-C	0.28	0.03	0.56
				4751	G-T	0.28	0	-

The yellow shaded genotypes involve the rare "T-C" haplotype. The low number of animals with this genotype in the data set made it difficult to accurately estimate the size of its effect.

*** The Angus CMP population was analyzed at a later date than the other sample populations and so this data is not included in the combined analysis.