EFFECT OF *DGAT1* POLYMORPHISM ON MEAT SHEAR FORCE AND COMPRESSION IN SWEDISH BEEF BREEDS

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***Abstract*— the objective of this study was to investigate the frequency of the *DGAT1 K232A* genotype in Swedish beef breeds and its effects on beef tenderness. Young bulls (n= 206) from five Swedish beef breeds were selected and shear force and compression were performed to evaluate meat tenderness characteristics. Within the Angus breed, animals with the heterozygous *KA* genotype of the *DGAT1* gene had significantly higher peak force (N) and total energy (N.mm) compared to those with the *AA* genotype ($P<0.05$). In conclusion, individuals with the *KA* genotype of the *DGAT1* gene showed significantly poorer tenderness characteristics compared to those with the *AA* genotype in the Angus breed whereas no significant differences were found for the other breeds.**

***Key words*— beef cattle, *DGAT1*, meat tenderness, polymorphism**

I. INTRODUCTION

Meat tenderness is a crucial trait in determining consumer satisfaction. The tenderness of meat could be affected by several factors such as type of muscle (Boles & Shand, 2008), *post mortem* time (King, Wheeler, Shackelford, Pfeiffer, Nickelson, & Koohmaraie, 2009) and genetics (Costello *et al*., 2007). Intramuscular fat (IMF) content, or marbling, is an important indicator of meat quality. A high degree of marbling improves meat quality as regards juiciness, flavour and tenderness (Crouse, Cundiff, Koch, Koohmaraie, & Seideman, 1989; Wheeler, Cundiff, & Koch, 1994). Diacylglycerol O-acyltransferase 1 (*DGAT1*) is a key enzyme in the final step of the triglyceride synthesis which is the main component in fat. Thus, *DGAT1* could be a factor that determines fat deposition in muscle (Thaller *et al*., 2003) and also affects meat tenderness through its relationship with marbling (Crouse *et al*., 1989; Wheeler *et al*., 1994).

II. MATERIALS AND METHODS

Animals and sampling

Young bulls (206 in total) from five Swedish beef breeds were selected which included Hereford (n=32), Charolais (n= 96), Angus (n= 33), Limousin (n= 32) and Simmental (n= 13). All animals were 12-17 months old and were raised in Swedish farms. The carcass weight ranged from 254 to 391 kg, the EUROP classification varied from O^- to R^+, and the EUROP fatness ranged between 2 and 4^+.

On day 7 *post mortem*, a 7 cm long piece of the *M. Longissimus dorsi* (LD), was cut out from one carcass side, starting from the 10th or 11th rib, for shear force and compression measurements. Samples were packed in vacuum and stored at -20 ℃ until analysis. Samples of muscle tissue for DNA test were taken from the front side of the LD cut, put in 1.5 ml micro tube and stored at -80 ℃ until DNA extraction.

Shear force and compression analysis

Warner Bratzler Shear force and compression were measured using the method as described by Honikel (1998) with some modifications. The frozen meat samples at -20 ℃ were thawed over night at 4 ℃ and then put in a water bath at room temperature for 30min to equilibrate temperature. The vacuum packed meat was heated in a 72 ℃ water bath until a core temperature of 70 ℃, and then cooled under running cold tap water for 30 min. The cooked samples were kept at 4 ℃ over night to get equilibrated temperature.

For each sample, twelve strips were cut out being at least 40 mm long and with a 100 mm^2 (10×10) cross-sectional area. The direction of muscle fibres was parallel to the longitudinal direction of the strip. The shear force and compression assessments were carried out 15 mm from each end of the strip, which made it possible to use the same strip for both test. The strips were tested on a Stable Micro System Texture Analyser HD 100 (Godalning, UK) for shear force and compression. For Warner Bratzler shear force test, the cutting blade was 1mm thick with a rectangular

shaped cutting area (11 mm×15 mm) and the speed was 0.83 mm/s when cutting through the strips. Shear force was recorded as peak force (N), total energy (N.mm) and shear firmness (N/mm) (Table 1; Honikel, 1998).

Compression measurements were conducted by a squared flat ended plunger (10×10 mm), which was driven with test speed of 1.60 mm/s vertically 80% of the way through the strips. The direction of muscle fibre was perpendicular to the direction of plunger penetration and the plunger was driven twice into the strips at the same point. The strips were placed in a metal cell (50 mm long×10 mm wide×20 mm high) with two lateral walls parallel to the longitudinal direction of the strips. During compression test, the resulting deformation of strips only happened in the direction parallel to the muscle fibre. Compression results were recorded as hardness (N), cohesiveness, gumminess, compression area 1 and 2 (N.mm) (Table 1; Honikel, 1998).

Table 1. Description of variables for shear force and compression analysis

Variables	Description
Shear force	
Peak force (N)	Maximum peak force
Total energy (N.mm)	area under the curve
Shear firmness (N/mm)	slope of the curve from its origin to its peak
Compression	
Hardness (N)	Maximum force for the first compression curve
Cohesiveness	Ratio of the area under the second curve to the area under the first curve
Gumminess	Hardness × cohesiveness
Area 1 and 2 (N.mm)	The area under the first and second compression curve

DNA test

DNA was extracted from muscle tissue using the Omega Bio-Tek Tissue DNA Kit. Allelic discrimination in *DGAT1* was carried out using Real-Time PCR with TaqMan chemistry (Applied Biosystems StepOnePlus™). The primer probes for this reaction were designed based on the *DGAT1* sequence (AY065621):

Forward: 5'-CGCTTGCTCGTAGCTTTGG-3'

Reverse: 5'-CGCGGTAGGTCAGGTTGTC-3'

VIC probe (detects the allele encoding 232K): 5'-CGTTGGCCTTCTTAC-3'

FAM probe (detects the allele encoding 232A): 5'-TTGGCCGCCTTAC-3'

Statistical analysis

Statistical analysis was carried out by the Mixed procedure in Statistical Analysis System (Version 9.1, SAS Institute, Cary, NC, USA). The model included breed as fixed effect. The single individual with the *KK* genotype was excluded when we tested the effects of genotype on meat traits.

III. RESULTS AND DISCUSSION

Table 2. Frequencies of *DGAT1 K232A* genotypes and the *232A* allele in five Swedish beef breeds

Breed	n	*KK* (%)	*KA* (%)	*AA* (%)	Allele *232A*
Angus	33	1 (3.0)	11 (33.3)	21 (63.6)	0.80
Charolais	96	0 (0.0)	19 (19.8)	77 (80.2)	0.90
Hereford	32	0 (0.0)	0 (0.0)	32 (100.0)	1.00
Limousin	32	0 (0.0)	4 (12.5)	28 (87.5)	0.94
Simmental	13	0 (0.0)	0 (0.0)	13 (100.0)	1.00

The frequency of genotype *AA* was higher than *KA* in all observed breeds and only one homozygous *KK* animal was observed, in the Angus breed (Table 2). The frequency of the *A* allele was considerably higher than the *K* allele in all breeds. Within the breeds of Hereford and Simmental, no individual with the *K* allele was found. The shear force and compression characteristics of animals from these five Swedish beef breeds are listed in Table 3.

Previous studies report very high frequencies of the *AA* genotype in *Bos taurus* (Winter *et al*., 2002; Moore *et al*., 2003) which is in agreement with our observations. In contrast, *Bos indicus* beef breeds seem to have a relatively high frequency of the *K* allele (Winter *et al*., 2002).

Table 3. Shear force and compression (least squares mean ± standard error) of *M. Longissimus dorsi* in five Swedish beef breeds

	Breed				
	Hereford	Charolais	Angus	Limousin	Simmental
Shear force					
Peak force (N)	50.2 ±2.7	45.3 ±2.0	37.4 ±2.9	52.0 ±4.1	54.4 ±4.3
Total energy (N.mm)	334.2 ±14.0	297.9 ±10.1	259.5 ±14.7	325.9 ±21.1	330.9 ±21.9
Shear firmness (N/mm)	6.5 ±0.3	5.9 ±0.2	4.4 ±0.3	6.3±0.5	7.4 ±0.5
Compression					
Hardness (N)	126.2 ±5.0	117.4 ±3.6	95.3 ±5.3	127.2 ±7.6	127.6 ±7.8
Cohesiveness*	6.7 ±0.2	7.9 ±0.2	7.7 ±0.2	9.8 ±0.3	7.7 ±0.3
Gumminess	843.2 ±43.7	916.1 ±31.6	737.3 ±46.0	1241.6 ±66.0	991.3 ±68.5
Area 1 (N.mm)	645.9 ±23.8	562.1 ±17.3	441.4 ±25.1	530.5 ±36.1	599.3 ±37.4
Area 2 (N.mm)	45.9 ±1.9	46.4 ±1.4	35.9±2.0	54.9 ±2.9	50.6 ±3.0

* Cohesiveness = Area 2/ Area 1*100

Table 4. Effect of *DGAT1 K232A* genotype on shear force and compression (least squares mean ± standard error) in three Swedish beef breeds

	Charolais		Angus		Limousin	
	KA	*AA*	*KA*	*AA*	*KA*	*AA*
Shear force						
Peak force (N)	44.1 ±3.3	46.5 ±1.6	40.6 ±2.0 [a]	34.1 ±1.5 [b]	50.9 ±11.2	53.1 ±4.3
Total energy (N.mm)	290.5 ±17.2	305.3 ±8.5	276.1 ±12.2 [a]	242.8 ±8.9 [b]	328.5 ±56.0	323.4 ±21.2
Shear firmness (N/mm)	5.9 ±0.4	6.0 ±0.2	4.6 ±0.3	4.2 ±0.2	6.3 ±1.3	6.3 ±0.5
Compression						
Hardness (N)	114.5 ±7.0	120.3 ±3.5	97.4 ±4.3	93.3 ±3.1	130.8 ±12.7	123.7 ±4.8
Cohesiveness	7.9 ±0.3	7.8 ±0.1	7.6 ±0.3	7.8 ±0.3	10.1 ±0.6	9.4 ±0.2
Gumminess	900.7 ±60.6	931.4 ±30.1	746.5 ±44.0	728.1 ±31.8	1320.1±124.8	1163.2 ±47.2
Area1 (N.mm)	545.7 ±33.5	578.5 ±16.6	453.4 ±23.2	429.4 ±16.8	539.8 ±63.6	521.3 ±24.0
Area2 (N.mm)	45.6 ±2.6	47.3 ±1.3	36.8 ±2.0	35.0 ±1.5	57.5 ±5.5	52.2 ±2.1

In the same row, means within breed with different letters are significantly different ($P< 0.05$).

The associations of *DGAT1 K232A* genotype with peak force and total energy were significant in the Angus breed ($P<0.05$, Table 4). Individuals carrying the *KA* genotype had less tender meat compared to those with the *AA* genotype.

Winter *et al*. (2002) detected the *DGAT1* polymorphism in bovine chromosome 14 and associated it with milk fat content. The mutation in *DGAT1* gene results in a substitution of lysine by alanine (*K232A*) where the *K* allele coding for the lysine variant of the enzyme is associated with higher milk fat content. Many studies have been done on the association between *DGAT1* polymorphism and milk composition (Kühn *et al*., 2004; Signorelli *et al*., 2009), but only few studies have tested the association of this polymorphism with meat quality traits (Thaller *et al*., 2003; Fortes, Curi, Chardulo, & Silveira, 2009; Souza *et al*., 2010). Fortes *et al*. (2009) did not find any association between *DGAT1* genotype and shear force. However, animals with high intramuscular fat content may have more tender meat due to the improvement of intramuscular fat content on meat juiciness and reduction on shear force (Crouse *et al*., 1989; Wheeler *et al*., 1994). Thaller *et al*. (2003) reported that animals with *KA* genotype had less intramuscular fat content than those with *AA* genotype, which is somewhat surprising considering the strong and positive effect of the *K* allele on milk fat content (Winter *et al*., 2002). In our study, Angus individuals with the *KA* genotype showed less tender meat characteristics (peak force and total energy) compared to those with the *AA* genotype ($P<0.05$).

IV. CONCLUSION

We found that individuals with the *KA* genotype of the *DGAT1* gene showed significantly poorer tenderness characteristics compared to those with the *AA* genotype in the Angus breed whereas no significant differences were found for the other breeds. Further research is necessary for detecting the association of *DGAT1* gene polymorphisms with intramuscular fat content and the correlation between intramuscular fat content and tenderness.

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