

The *Callipyge* Sheep:

**A model for developing laboratory skills
in muscle growth and meat quality**



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The Course:

ADSC 6170 – Experimental Techniques in Meat Science and Muscle Biology

Objectives:

- 1) Provide hands-on, experiential learning
- 2) Practice scientific manuscript writing
- 3) Develop skills in proposal writing

The Process:

Harvest to Consumption

- ◆ Rigor development
 - pH and R-values
- ◆ Carcass Composition
 - muscle dissection
 - chemical & NIRS
- ◆ Enzymology
 - protein separation
 - calpain system
 - kinetics
- ◆ Collagen content
- ◆ Sarcomere length
- ◆ Muscle growth
 - RNA/DNA/protein
- ◆ Fiber size and type
 - red, white, intermediate
- ◆ SDS-PAGE
 - protein separation
- ◆ Sensory analysis
- ◆ Textural analysis

The Model: *Callipyge* Sheep



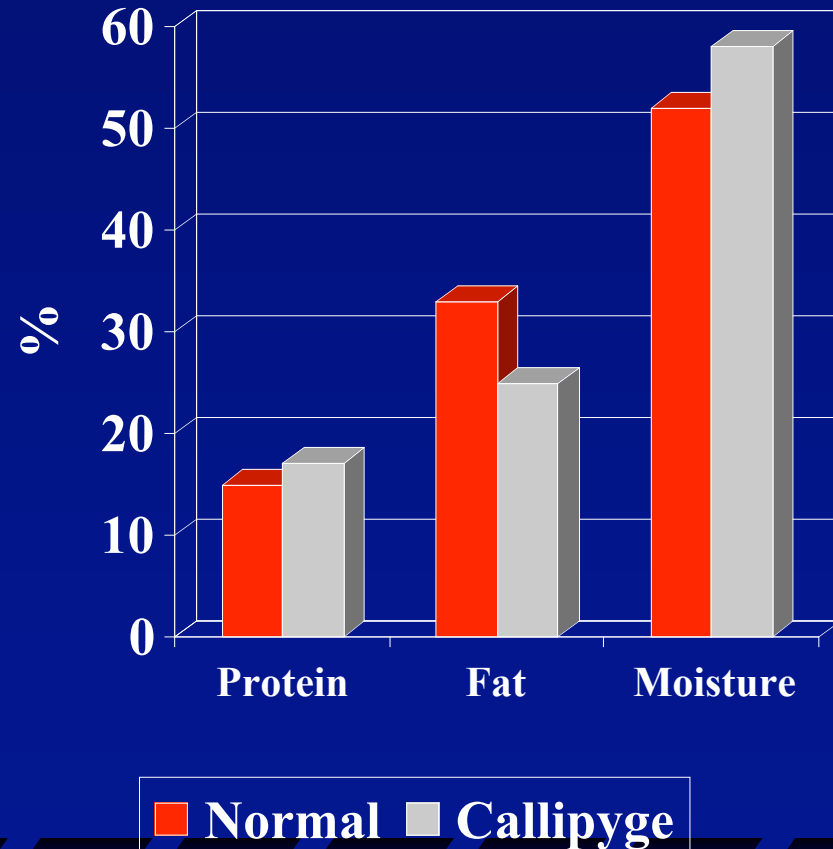
- ◆ Aphrodite Kallipygos
- ◆ “Beautiful buttocks”
- ◆ Single gene mutation

The Model: *Callipyge* Sheep

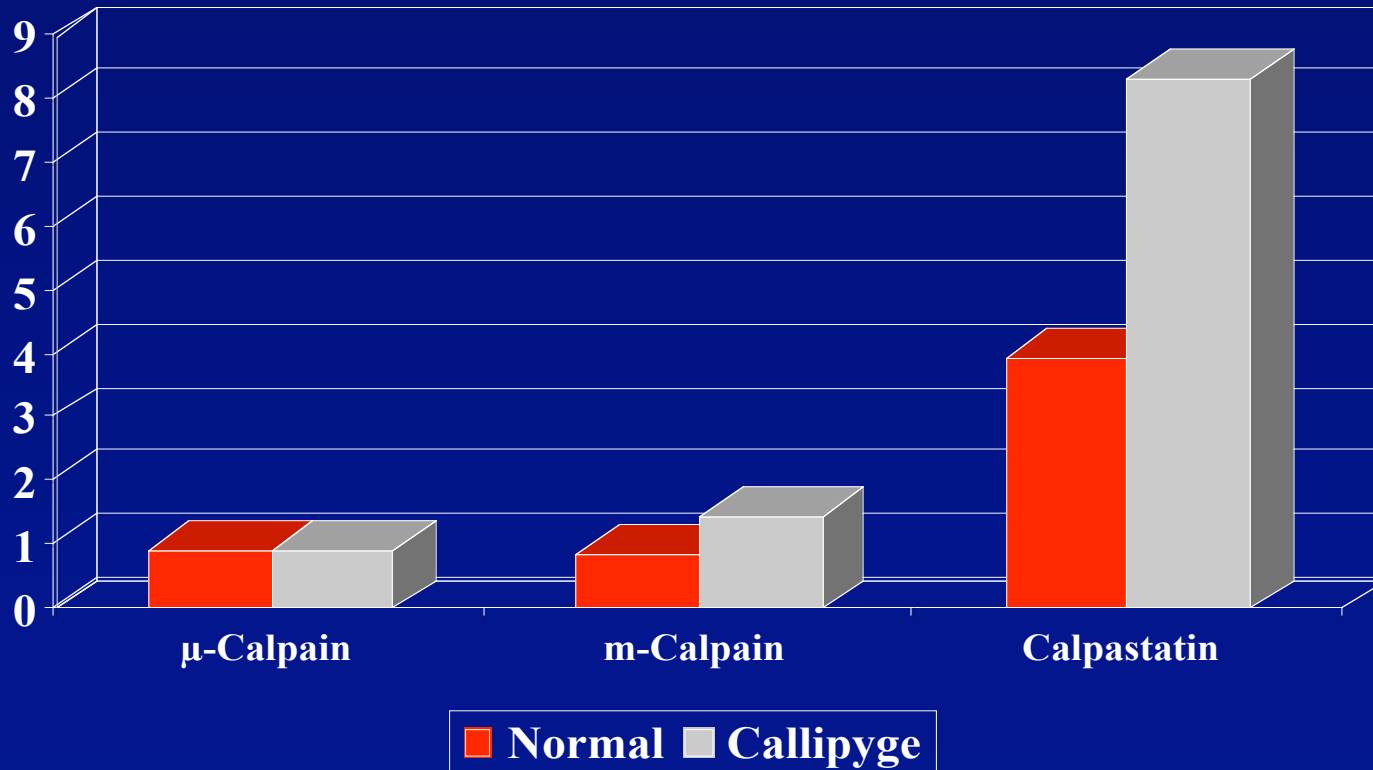


- ◆ Aphrodite Kallipygos
- ◆ “Beautiful buttocks”
- ◆ Single gene mutation
- ◆ Extreme muscle growth
- ◆ Compromised tenderness

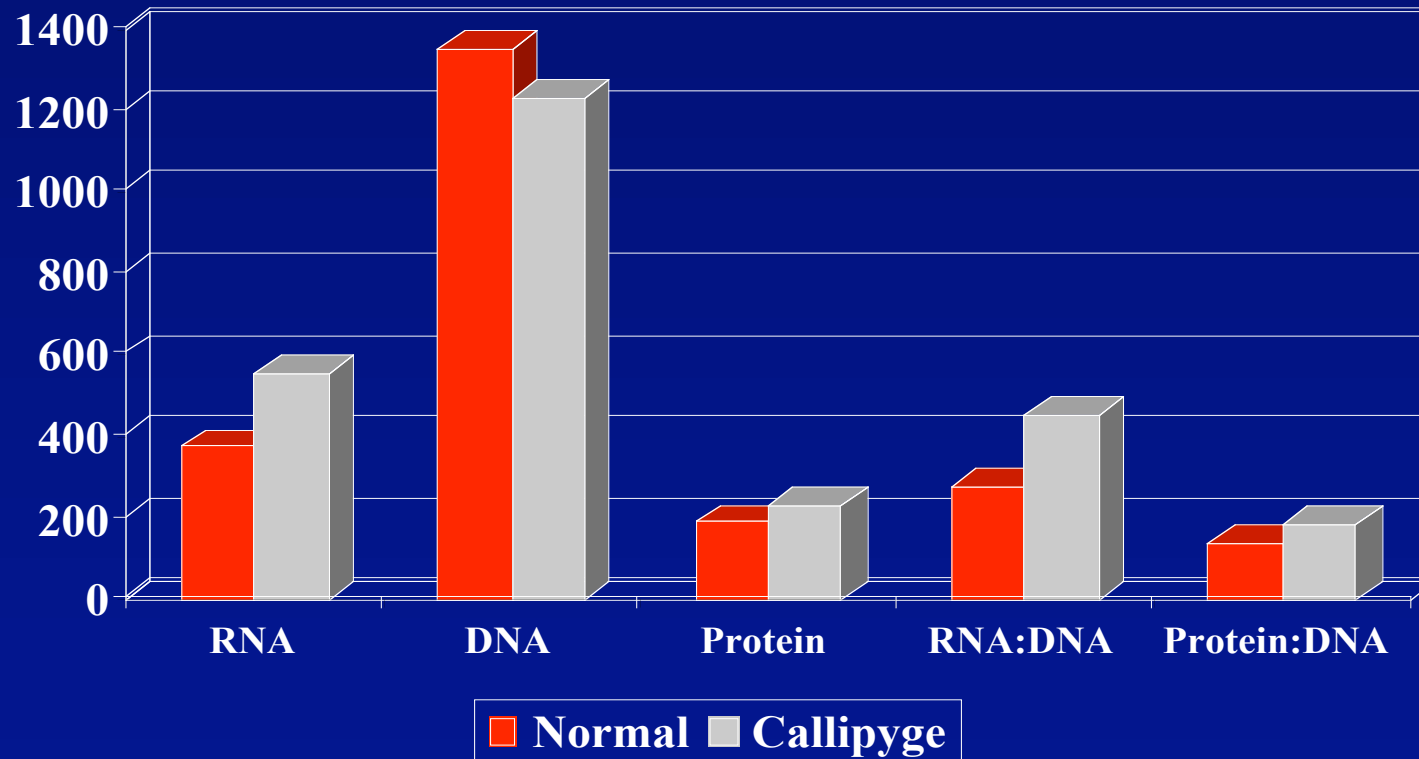
Carcass composition: Near infrared reflectance spectroscopy



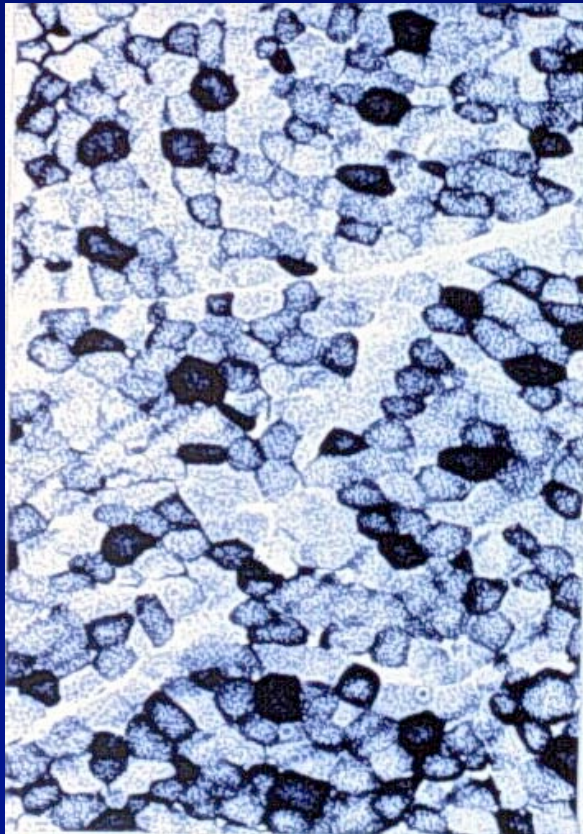
Protein separation: the calpain proteinase system



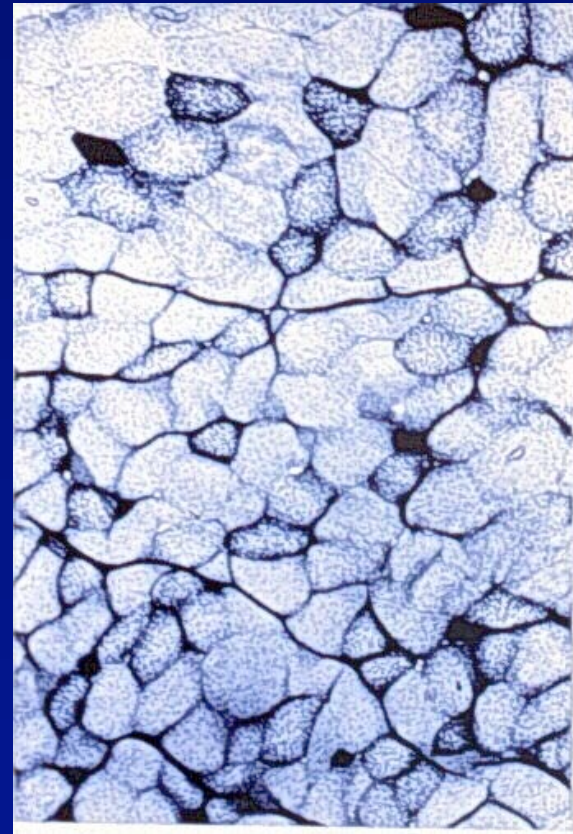
Muscle growth indicators: RNA / DNA / Protein



Fiber type and distribution



Normal



Callipyge

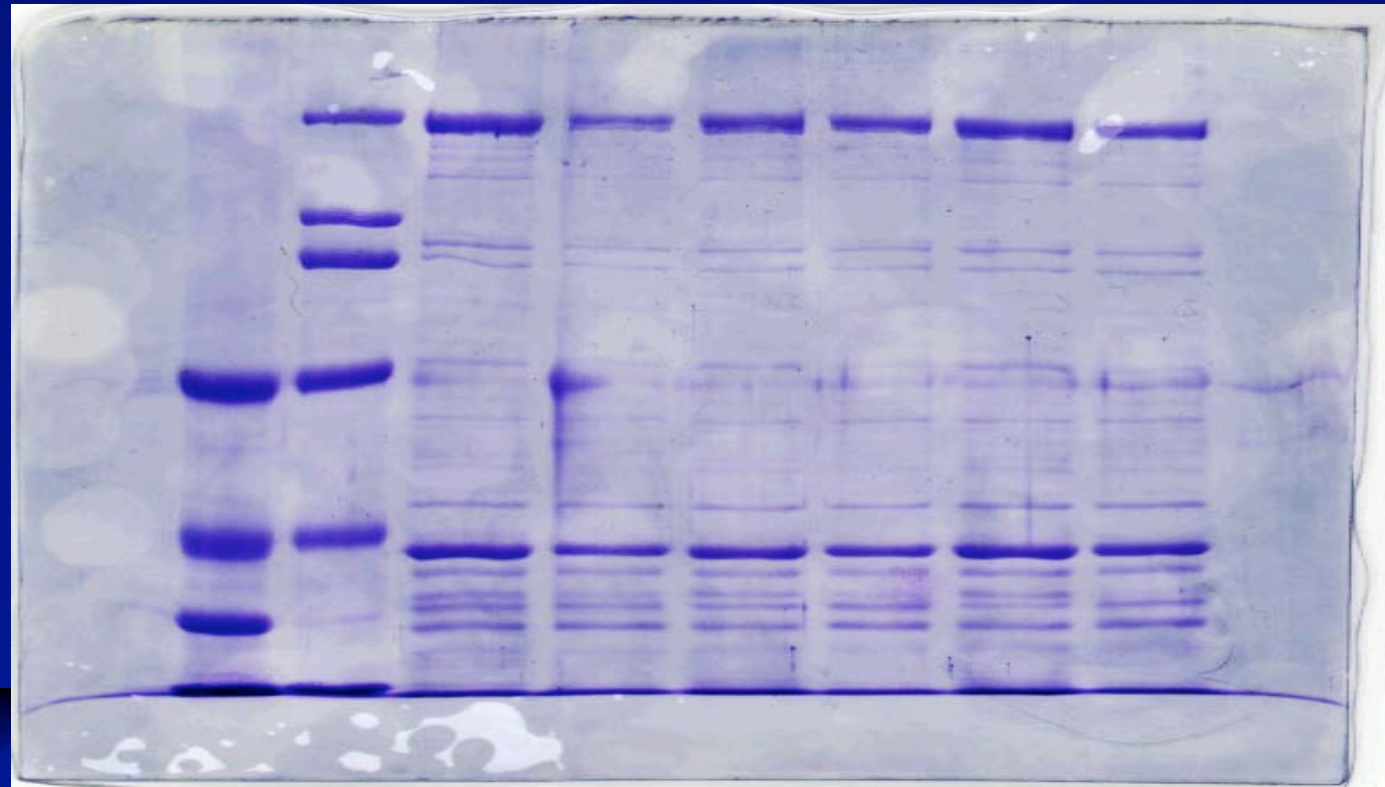
Protein separation: SDS-PAGE of muscle proteins – Aging effects

LMW HMW Normal-Muscled Callipyge
1d 7d 14d 1d 7d 14d

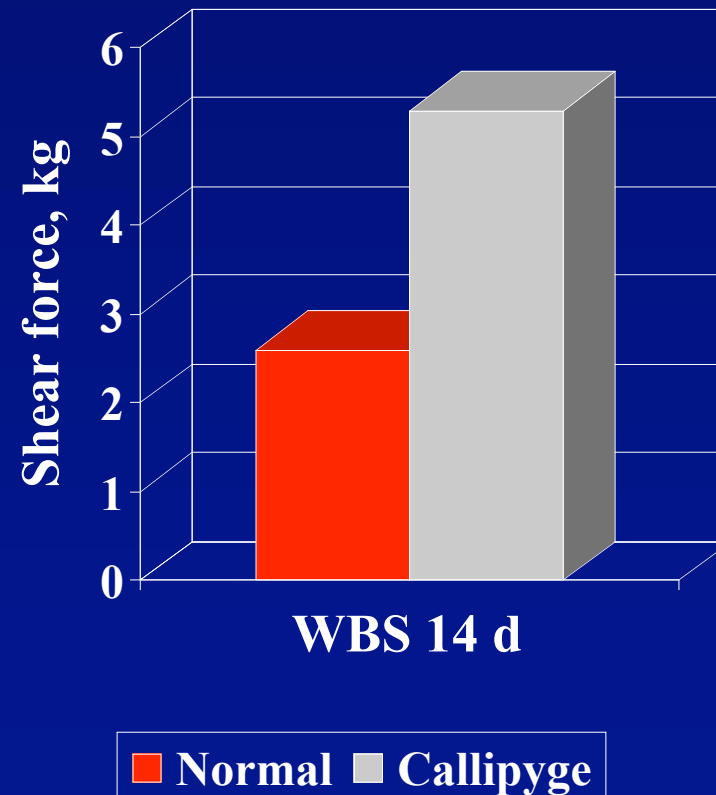
205 kd
116 kd
97.4 kd

66 kd

45 kd
36 kd



Instrumental Tenderness: Warner Bratzler shear force



The Coup de Grace: Scientific writing

Evaluation of Physiological and Biochemical Characteristics, Postmortem Proteolysis, Calpain/Calpastatin Activity and Tenderness in Callipyge and Normal Lamb

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ABSTRACT: The present experiment was conducted to determine the effect of the callipyge phenotype on composition traits and many attributes closely related to tenderness. Two lambs, one carrier and one non-carrier of the callipyge gene, were slaughtered. The callipyge lamb did have higher weights for 12 muscles, especially those muscles in the hindsaddle. Phenotype did not affect temperature decline, pH or R-values postmortem. Longissimus MFI was lower at 2 and 21 d postmortem and WBS was higher at 2 and 21 d postmortem for the callipyge phenotype. Calpastatin activity was higher for the callipyge but there was no difference in m-calpain. Collagen content was higher for the normal phenotype. DNA, RNA and protein concentrations in this study did not agree with previous studies. The SDS-PAGE showed less myofibril degradation in the callipyge muscle. Due to decreased fat content, the callipyge phenotype had a lower TBARS concentration. These results show higher protein synthesis and reduced protein degradation of the callipyge phenotype.

Keywords: Callipyge, Calpain, Calpastatin, Postmortem Changes, Tenderness

Introduction

A heritable muscular hypertrophy condition in sheep has been identified (Freking et al., 1998). The callipyge phenotype is inherited in a non-Mendelian pattern. Heterozygous individuals that inherited the gene from the sire are the ones that display the phenotype (Freking et al., 1998). This muscle hypertrophy condition provides a number of advantageous traits to the sheep production industry. The callipyge phenotype greatly improves lamb carcass composition (Koochmaria, 1995) thus allowing the lamb industry to increase the efficiency of lean meat production. However, this improvement in lean composition comes with a price. It is well documented that this hypertrophy condition greatly reduces longissimus tenderness and postmortem aging occurs at a slower rate than in normal lambs (Koochmaria, 1995; Duckett, 2000; Shackelford, 1997). This decrease in tenderness compared to normal phenotypes seems to be associated with an increased elevation in calpastatin activity (Koochmaria, 1995). The objective of the present study was to determine the effects of the callipyge gene on composition traits and attributes closely related to meat quality and tenderness.

Carcass Dissection and Proximate Composition. Individual dissected weights are reported in table 1. The actual weights of the two types of carcasses, normal-muscle and callipyge, were as expected. Callipyge lambs should produce a heavier muscled carcass especially in the hindsaddle. The percentage of the side weight for carcass lean for the callipyge lamb was approximately nine percent higher. Also as expected, callipyge lambs will be slightly lighter boned and have a much higher muscle to bone ratio. The specific gravity of the two types of lambs did not differ. The normal-muscle lamb had a specific gravity of 1.045 and the callipyge lamb had a specific gravity of 1.043. Since there was no difference in specific gravity, the prediction equations were not able to accurately determine percent fat and lean for the two carcasses (figures not shown). The prediction equations underestimated the lean percentage and overestimated the fat percentage. Nor could the prediction equations take into account the differences in the two carcass types.

As expected, the proximate compositions showed the callipyge lamb to have a higher protein percentage and water percentage and the normal-muscle lamb to have a higher fat percentage (table 2). The data did show the inverse relationship of fat to water. However, the nitrogen analyzer showed a slightly higher percentage of protein in both sample types than the NIT. But this is to be expected because the nitrogen analyzer would take into account all protein (sarcoplasmic, myofibrillar and collagen).

Table 1. Effect of phenotype on dissected muscle weights and percentage of total carcass weight for twelve muscles

Muscle	Normal		Callipyge	
	Weight, kg	% of the side	Weight, kg	% of the side
Gluteus medius	0.35	2.5	0.46	3.0
Biceps femoris	0.45	3.3	0.54	3.6
Semitendinosus	0.17	1.2	0.19	1.3
Semimembranosus	0.67	4.9	0.87	5.7
Adductor	0.16	1.2	0.18	1.2
Psoas major and minor	0.18	1.3	0.28	1.8
Longissimus dorsi	0.90	6.6	1.19	7.9
Subscapularis	0.08	0.6	0.09	0.6
Triceps brachii	0.36	2.7	0.30	1.9
Supraspinatus	0.20	1.5	0.15	1.0
Infraspinatus	0.27	2.0	0.23	1.5
Deep pectoral	0.25	1.8	0.37	2.4

Summary: The *Callipyge* Model

◆ Advantages

- Plethora of literature
- Large differences in measured traits
- Simulates real-world research
- Continuum from harvest to consumption

◆ Disadvantages

- Extremely tough so not used commercially
- Availability is limited

◆ Student Comments

- ... “helpful to follow a ‘project’ all the way through and tie it all together at the end.”
- “Writing exercises such as journal article and the proposal were very informative and helpful”

Other Models?

- ◆ β -agonist treated lambs

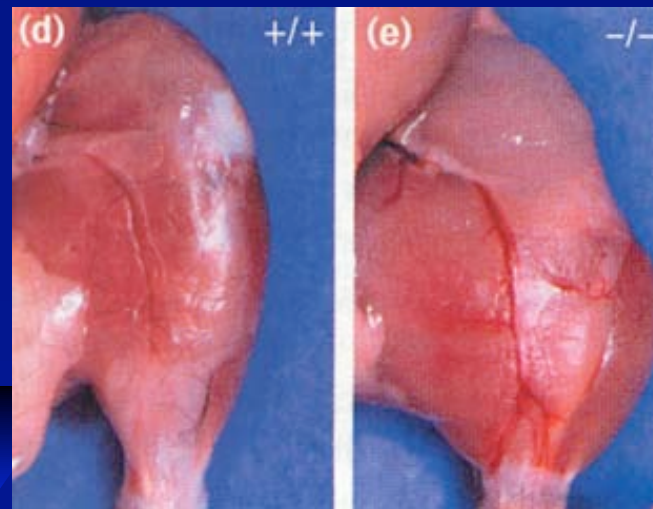
Other Models?

- ◆ β -agonist treated lambs
- ◆ Double-muscled cattle



Other Models?

- ◆ β -agonist treated lambs
- ◆ Double-muscled cattle
- ◆ Myostatin knockouts



The End





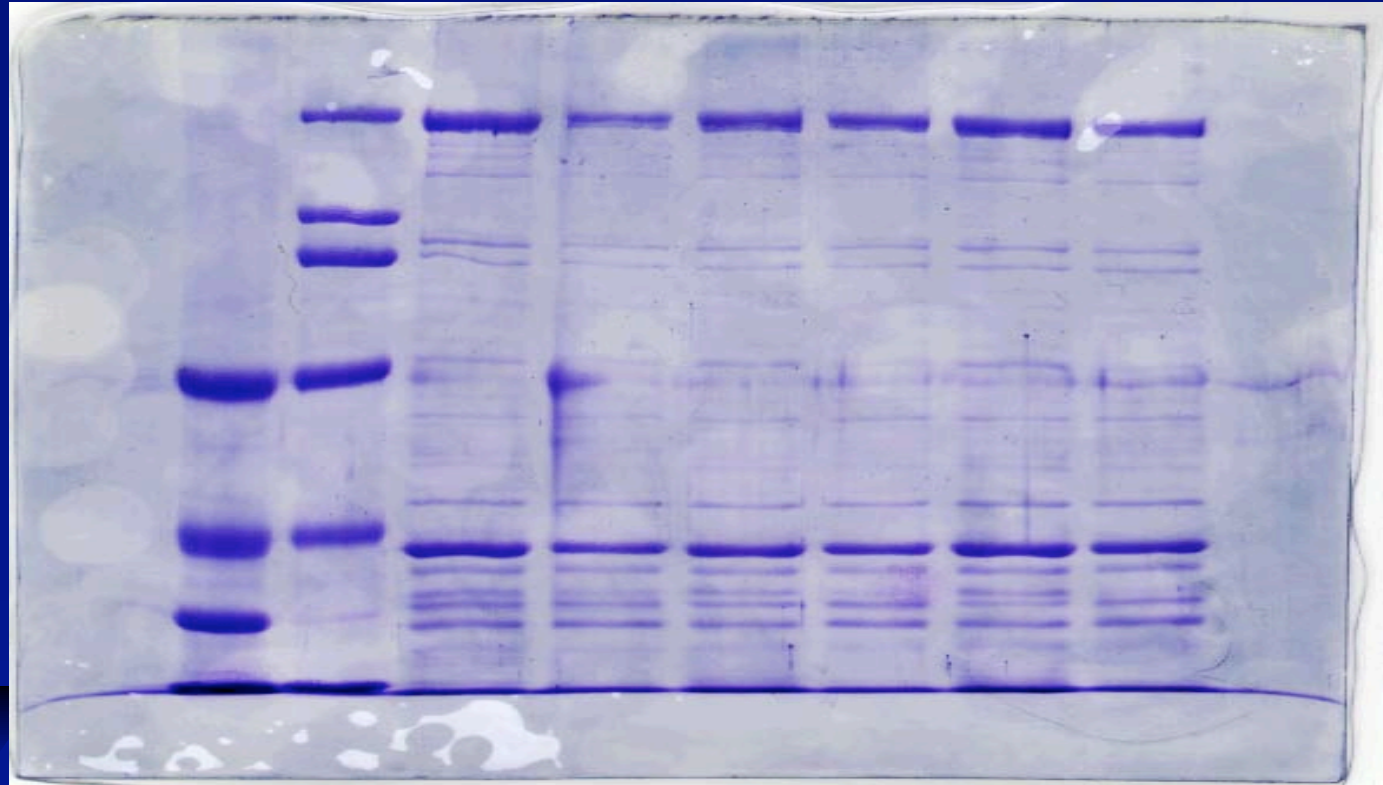
Electrophoresis (SDS-PAGE) of postmortem muscle proteolysis

LMW HMW Normal-Muscled Callipyge
1d 7d 14d 1d 7d 14d

205 kd
116 kd
97.4 kd

66 kd

45 kd
36 kd



SDS-PAGE of DEAE-purified Calpains and Calpastatin

LMW HMW Calpastatin μ -Calpain m-Calpain
 NM DM NM DM NM DM

205 kd

116 kd

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66 kd

45 kd

36 kd

