Physiological and Transcriptional Adaptations in Skeletal Muscle of Holstein Cows in Response to Plane of Dietary Protein during Early Lactation

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INTRODUCTION

- Feeding lower dietary protein (CP < 16% of DM) increased N efficiency and maintained production in field studies.
- Dairy cows experience negative protein balance during early lactation.
- High producing cows mobilize up to 1000 g/d of tissue protein to support milk protein or for gluconeogenesis during first 7 to 10 days in milk (**DIM**).

OBJECTIVE

- Investigate transcriptional adaptation and proteolytic activity of skeletal muscle of high producing cows in response to plane of dietary and metabolizable protein during early lactation.

MATERIALS AND METHODS

Completely Randomized Design

- Thirty-one multiparous Holstein cows (a subset of a larger study)
- Treatments:
  - **LL**: a low CP (15% DM) diet (1 to 91 DIM, n = 9)
  - **HL**: a high CP (17.5% DM) diet (1 to 21 DIM), and a low CP diet (22 to 91 DIM, n = 11)
  - **HM**: a high CP diet (1 to 21 DIM), and a medium CP (16.2% DM) diet (22 to 91 DIM, n = 11)

Data Collection

- Milk yield and DMI (daily), and milk composition (weekly)
- Plasma 3-methylhistidine (**3-MH**) and serum creatinine (**CRE**) (1, 7, 13, 19, 26, 40, 54, 68, and 82 DIM)
- Semitendinosus muscle biopsy (2, 11, and 62 DIM)
- Gene expression:
  - RNA extraction: 100 mg tissue, QIAzol + miRNeasy Micro Kit (QIAGEN)
  - Primer design: Primer Express 3.0
  - RT-qPCR: standard curve method for relative mRNA expression
  - Normalization with geometric mean of 3 internal control genes

Statistical Analysis

- ANOVA with MIXED procedure of SAS
  - Repeated measures for unequally spaced interval of sampling
  - Fixed effect: treatment, DIM
  - Random effect: cow within treatment
  - Natural logarithmic transformation for gene expression as needed

RESULTS

Table 1. Nutrient composition of diets[1].

Items	Low CP diet	Moderate CP diet	High CP diet
CP, % DM	15.3 ± 0.1	16.2 ± 0.1	17.0 ± 0.1
Neutral detergent fiber, % DM	35.6 ± 0.3	34.4 ± 0.2	33.3 ± 0.3
Starch, % DM	24.2 ± 0.2	24.5 ± 0.2	24.6 ± 0.3
NE_L, Mcal/kg DM	1.64 ± 0.01	1.64 ± 0.01	1.65 ± 0.01
Metabolizable protein supply, g/d[2]	1798	1895	1999

[1]See detailed feed ingredient composition of diets at abstract W51
[2]Estimated with NDS (v3) for 19.1 kg dry matter intake

Table 2. Intake and production performance from calving to wk 9 of lactation.

Items	LL	HL	HM	SEM	*P*-value		
					Trt	DIM	T × D
DMI, kg/d	25.9	26.0	25.1	0.80	0.58	<0.001	0.19
CP intake, kg/d	3.79	3.95	4.20	0.12	0.06	<0.001	0.02
NE_L intake, Mcal/d	41.6	41.9	40.3	1.21	0.56	<0.001	0.14
Milk yield, kg/d	48.3	49.9	51.4	2.66	0.70	<0.001	0.44
Fat, kg/d	1.87	1.91	1.91	0.07	0.88	<0.001	0.11
Fat, %	3.70	3.74	3.69	0.17	0.98	<0.001	0.49
True protein, kg/d	1.48	1.49	1.47	0.06	0.94	0.046	0.21
True protein, %	2.93	2.91	2.81	0.08	0.51	<0.001	0.69
MUN, mg/dL	8.47	8.99	11.66	0.43	<0.001	<0.001	<0.001

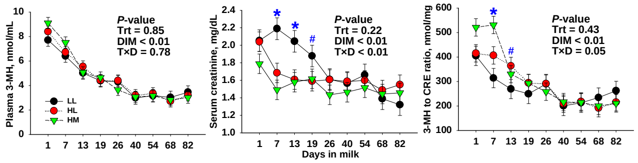

Figure 1. Plasma 3MH, CRE, and ratio of 3-MH/CRE. Contrast performed between LL and (HL+HM) before 19 DIM. * for significance (*P* < 0.05), and # for tendency (*P* < 0.10).

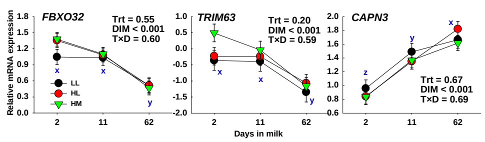

Figure 2. Genes involved in proteolysis. Different letters indicated significant difference among DIM (*P* < 0.05), same for other figures).

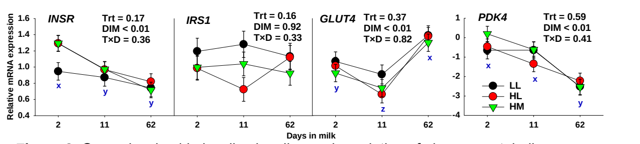

Figure 3. Genes involved in insulin signaling and regulation of glucose metabolism.

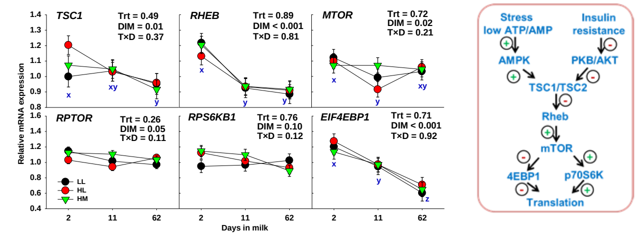

Figure 4. Genes involved in mTORC1 signaling and protein synthesis.

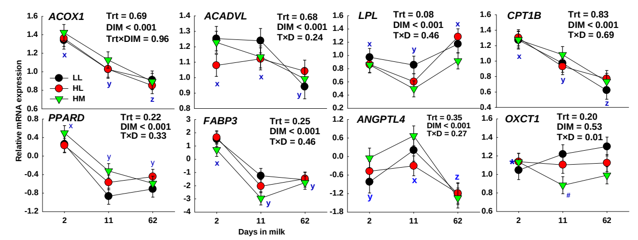

Figure 5. Genes involved fatty acid uptake, β-oxidation and ketone body catabolism.

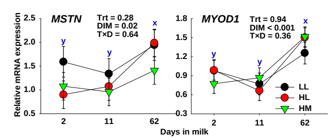

Figure 6. Genes involved in myogenesis.

CONCLUSIONS

- Feed intake and lactation performance were not affected by plane of dietary protein in early lactation.
- Moderate reduction of dietary protein (by 1% of DM) did not amplify the breakdown of skeletal muscle during early lactation.
- The physiology of early lactation rather than dietary protein level coordinated transcriptional adaptation of genes in skeletal muscle, which may facilitate proteolysis, sparing glucose, and using fatty acid as energy substrates.

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