Towards the Identification of Indicators for Metabolic Stress in Dairy Cattle

A.S. Leaflet R2091

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Summary and Implications

Cows representing the average (AFP) and high (HFP) fat plus protein selection lines maintained at the ISU dairy were selected to participate in a study to identify indicators of energy mobilization. Differences between HFP and AFP cows in the expression of genes in adipose tissue, and the production of metabolic hormones are being defined. These differences will reveal physiological mechanisms important to the mobilization and utilization of energy reserves. This work will lead to the identification of indicators of metabolic stress, and aid in the selection of dairy cattle better able to sustain optimal levels of milk production.

Introduction

Metabolic stress represents the portion of negative energy balance that cannot be sustained by dairy cows. As a result, some energetic processes, including those that maintain good health and fertility, must be down-regulated. Although declining population trends for health and reproduction traits suggest dairy cattle are experiencing increasing levels of metabolic stress, metabolic stress is currently difficult to measure in individual animals. The identification of specific physiological indicators of metabolic stress would be useful for identifying cows resistant to metabolic stress, but capable of maintaining optimal levels of milk production over multiple lactations.

Materials and Methods

Selection for high or average fat plus protein has been practiced since the late 1980's in the HFP and AFP, respectively, lines of Holstein cattle in the ISU dairy herd. Five second parity cows were selected from each line based on their first lactation record and genetic evaluation to maximize differences in the production of milk and milk components. Body weight and body condition score were recorded weekly for 4 weeks prior through 6 weeks post calving. Adipose tissue biopsies were taken 5 and 21 days after calving, and a third biopsy will be taken 140 days after calving. Gene expression profiles of HFP and AFP cows will be compared at each time point to define genes associated with differences in the mobilization of adipose tissue in response to energy demands of lactation. In a second experiment, weekly blood samples are being collected from 10 first and 10 second lactation cows of each line from week -4 through week 12 relative to calving. These samples will be analyzed to determine differences in metabolites representing mobilization of fat and muscle tissue, as well as hormones that contribute to the regulation of energy mobilization.

Results and Discussion

Phenotypic differences between cows (n=5 per line) selected from the HFP and AFP lines are represented in Table 1. Milk, fat and protein phenotypes represent production from their first lactation. Genetic values (PTA's) are from the August, 2005, USDA genetic evaluation. These values demonstrate that significant differences in production potential have been achieved through development of the HFP and AFP lines. As energy balance, gene expression, and other physiological differences between cows representing these lines are defined, a greater understanding of the relationships of these traits with production and fitness traits will be gained. The long-range goal of this research is to identify effective indicators of metabolic stress. This will facilitate the identification of cows capable of optimal milk production that are able to maintain sufficient body energy reserves to support reproduction and immune functions, thereby improving overall production efficiency.

Table 1. Average 305 day milk, fat and protein production and predicted transmitting ability (PTA) of cows chosen to represent lines of Holstein cattle selected for high (HFP) or average (AFP) fat plus protein PTA (n=5 cows per line).

	Milk	ECM[a]	Fat	Protein	Milk PTA	Fat PTA	Protein PTA
HFP	28,529	30,740	1181	893	460	51	31
AFP	24,593	24,338	868	738	-630	-18	-16

[a]Energy corrected milk: the amount of energy in milk based on milk, fat, and protein production, adjusted to 3.5% fat and 3.2% protein