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Analysis of Milk Urea Nitrogen and Lactose and Their Effect on Longevity in Canadian Dairy Cattle

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ABSTRACT

The aim of this study was to assess the phenotypic level of lactose and milk urea nitrogen concentration (MUN) and the association of these traits with functional survival of Canadian dairy cattle using a Weibull proportional hazards model. A total of 1,568,952 test-day records from 283,958 multiparous Holstein cows from 4,758 herds, and 79,036 test-day records from 26,784 multiparous Ayrshire cows from 384 herds, calving from 2001 to 2004, were used for the phenotypic analysis. The overall average lactose percentage and MUN for Ayrshires were 4.49% and 12.20 mg/dL, respectively. The corresponding figures for Holsteins were 4.58% and 11.11 mg/dL. Concentration of MUN increased with parity number, whereas lactose percentage decreased in later parities. Data for survival analysis consisted of 39,536 first-lactation cows from 1,619 herds from 2,755 sires for Holsteins and 2,093 cows in 228 herds from 157 sires for Ayrshires. Test-day lactose percentage and MUN were averaged within first lactation. Average lactose percentage and MUN were grouped into 5 classes (low, medium-low, medium, medium-high, and high) based on mean and standard deviation values. The statistical model included the effects of stage of lactation, season of production, the annual change in herd size, type of milk-recording supervision, age at first calving, effects of milk, fat, and protein yields calculated as within herd-year-parity deviations, herd-year-season of calving, lactose percentage and MUN classes, and sire. The relative culling rate was calculated for animals in each class after accounting for the remaining effects included in the model. Results showed that there was a statistically significant association between lactose percentage and MUN in first lactation with functional survival in both breeds. Ayrshire cows with high and low concentration of MUN tended to be culled at a higher than average rate. Instead, Holstein cows had a linear association, with decreasing relative risk of culling with increasing levels of MUN concentration. The relationship between lactose percentage and survival was similar across breeds, with higher risk of culling at low level of lactose, and lower risk of culling at high level of lactose percentage.
Key words: milk urea nitrogen, lactose, longevity

INTRODUCTION

Traditional milk recording by DHI organizations includes collection of milk weights and samples for each cow. Milk samples are sent to the lab for analysis of fat and protein content, and for counting of somatic cells. More recently, DHI labs also are analyzing the milk samples for MUN and for the percentage of lactose. Valacta, the DHI organization responsible for milk recording in Québec (previously known as PATLQ), has been collecting data on lactose in Québec dairy herds since 2001 and on MUN since 1997. Although data on MUN are being collected in other Canadian provinces, testing for lactose percentage in Canada is currently done exclusively by Valacta in Québec. Concentrations of MUN are measured at Canadian DHI labs by infrared technology. Infrared MUN values are calculated from prediction equations that use spectrum analyses and are an indirect measure of MUN. Wet chemistry methods, which directly measure concentration of urea nitrogen in milk samples, can also be used to measure MUN. Because of higher costs of wet chemistry analysis, infrared methodology is commonly used by DHI in Canada.

Milk urea nitrogen is a normal NPN component in milk. Urea is a major end-product of nitrogen metabolism in dairy cows. It is synthesized primarily in the liver and transported in blood to the kidney to be excreted in urine. From the blood, its concentration equilibrates rapidly with other body fluids, including milk (Gustafsson and Palmquist, 1993). Urea originates mainly from excess ammonia released from dietary protein degradation in the rumen or from deamination of amino acids in excess of requirements. Small amounts can also be derived from arginine catabolism in the

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mammary gland (Nousiainen et al., 2004). Milk urea nitrogen has been used as a noninvasive measurement to monitor the animal's protein status and the efficiency of nitrogen utilization (Moore and Varga, 1986; Broderick and Clayton, 1997; Jonker et al., 1998; Eicher et al., 1999). Several studies have been carried out to relate levels of MUN with reproductive performance. Mitchell et al. (2005) found that higher wet chemistry MUN was associated with more days open. However, they did not find any association between infrared MUN and reproduction traits. Guo et al. (2004) found small negative effects of elevated levels of MUN on conception rate within herds, but high MUN was not associated with reduced conception rates among herds. A study in the United Kingdom (Cottrill et al., 2002) found no association between bulk tank MUN and fertility, and no significant difference between the MUN concentration of the cows that became pregnant and those that did not. Concentration of MUN in Ontario herds has been shown to be heritable, but with low genetic correlations with production traits (Wood et al., 2003). Lower heritability values for MUN have been found in 2 US studies (Vallimont et al., 2003; Mitchell et al., 2005).

The level of water secretion into milk largely determines the fat and protein content of milk. The rate of water secretion is mostly determined by the rate of lactose synthesis, because lactose is the major factor responsible for the osmolality of milk. Several studies have investigated the relationship of lactose content with fertility. Francisco et al. (2003) concluded that lactose percentage seemed a good predictor of days to first and second postpartum ovulation. Buckley et al. (2003) found that higher lactose percentage was associated with increased pregnancy rate. Reksen et al. (2002) demonstrated that higher lactose percentage in first 8 wk postpartum was related to early luteal response in second-parity cows. Fat to lactose ratio has been shown to be an indicator of subclinical and clinical ketosis (Steen et al., 1996) and the most informative trait for estimation of energy balance (Reist et al., 2002). Lactose percentage has been found to be highly heritable (0.53) in Holstein cows from Michigan (Welper and Freeman, 1992).

Although there are several studies that have investigated the association of MUN and lactose with fertility, health, or energy balance traits, there are no studies in the literature that have investigated the association of MUN and lactose with longevity. Survival analysis using a Weibull proportional hazards model can offer better fit to survival data due to its ability to properly account for censored records. The model also accounts for the skewed distribution of survival data. Time-dependent variables can be used in the survival analysis to accurately model the effects of environment (Ducrocq and Sölkner, 1998; Vukasinovic, 1999; Ducrocq, 2002). Survival analysis has been used in numerous studies to assess the effect of various traits on functional longevity (Larroque and Ducrocq, 2001; Caraviello et al., 2003; Schneider et al., 2003; Sewalem et al., 2004). Because MUN concentration and lactose percentage have been associated with fertility, health, or energy balance traits, it might be expected that they indirectly influence the longevity of cows on farms.

Objectives of this study were 1) to perform a phenotypic analysis of MUN concentration and lactose yield and percentage in multiparous Ayrshire and Holstein cows; and 2) to analyze the association of first-lactation MUN and lactose percentage with cow functional longevity in Ayrshire and Holstein cows using the proportional hazards model.

MATERIALS AND METHODS

Test-day records from 2001 to 2004 were provided by Valacta for Québec farms that included test date, milk yield, fat, protein, and lactose percentages, SCC, MUN concentration, number of milkings per day, and a flag indicating supervised/unsupervised control. The data set included all Canadian dairy breeds. However, only records from Holstein and Ayrshire breeds were kept due to the low number of observations in Quebec for other breeds. Records from DIM lower than 5 and greater than 305 d were eliminated. A total of 1,568,952 test-day records from 283,958 multiparous Holstein cows from 4,758 herds, and 79,036 test-day records from 26,784 multiparous Ayrshire cows from 384 herds, calving from 2001 to 2004, were used for the phenotypic analysis. All samples were analyzed by midinfrared spectroscopy using Fossomatic 4000 milk analyzers (Foss Electric, Hillerød, Denmark) calibrated (wavelength = 9.6 μm) weekly. Calibration samples were analyzed for anhydrous lactose by HPLC (IDF Standard 198/ISO 22662; ICAR, 2006) and for MUN by pH difference (IDF Standard 195/ISO 14637). Test-day records of MUN and lactose yield and percentage were averaged and plotted by DIM for the first 3 parities. Also, test-day records of MUN and lactose percentage were averaged by month and by year of testing for the first 3 parities.

Data were then additionally edited for inclusion in the survival analysis. Only first-lactation cows were included in the survival analysis. Cows were required to have at least 3 test days, with the first test-day record occurring before 60 DIM. Furthermore, records associated with missing sire identification, incorrect calving dates, age at first calving outside the 18 to 40 mo range, and parities greater than 1 were excluded from the analysis. The final data set for Holsteins con-