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Nitrogen efficiency of eastern Canadian dairy herds: Effect on production performance and farm profitability

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ABSTRACT

Nitrogen efficiency (milk N/dietary N; NE) can be used as a tool for the nutritional, economic, and environmental management of dairy farms. The aim of this study was to identify the characteristics of herds with varying NE and assess the effect on farm profitability. One hundred dairy herds located in Québec, Canada, comprising on average 42 ± 18 cows in lactation were visited from October 2014 to June 2015. Feed intake was measured over 24 h. Samples of each feedstuff were taken and sent to a commercial laboratory for analysis of chemical composition. Feeding management and feed prices were recorded. Milk yield was recorded and milk samples were collected over 2 consecutive milkings. Fat, protein, and milk urea N were analyzed. Balances of metabolizable protein (MP; MP supply − MP requirements) and rumen degradable protein (RDP; RDP supply − RDP requirement) were calculated. A hierarchical cluster analysis was conducted and allowed grouping the farms by their NE. Four clusters were identified with an average NE of 22.1 (NE22), 26.9 (NE27), 30.0 (NE30), and 35.8% (NE36). Herds in clusters NE30 and NE36 were fed diets with greater concentrations of starch, net energy for lactation, and nonfiber carbohydrates than those in the other 2 clusters. Moreover, the average proportion of corn silage was lower for herds in cluster NE22 compared with NE30 and NE36 (8.23 vs. 31.8 and 31.3% of total forages, respectively). In addition, crude protein of the diets declined from an average of 16.0 to 14.9% with increasing NE among clusters. Average dry matter intake declined from 26.1 to 22.5 kg/d as NE of clusters increased. Herds in cluster NE22 had lower yields of milk (28.7 vs. 31.8 kg/d), fat (1.15 vs. 1.29 kg/d), and protein (0.94 vs. 1.05 kg/d) than the other clusters. Also, milk urea N was greater for farms in cluster NE22 (13.2 mg/dL) than for farms in the other clusters (11.4 mg/dL). Furthermore, MP and RDP balances decreased from 263.2 to −153.7 g/d and from 594.7 to 486.9 g/d, respectively, with increasing NE among clusters. Income over feed cost increased from \$14.3 to \$17.3/cow per day (Can\$) as NE among clusters augmented. Results from this study showed that some farms were able to achieve high NE by using lower levels of dietary N and having cows with lower DMI while maintaining milk performance. These farms had a potentially lower environmental impact, and they were more profitable.
Key words: nitrogen efficiency, commercial dairy farm, cluster analysis, income over feed cost

INTRODUCTION

Nitrogen excretion is directly related to N intake (Rotz, 2004). Studies have shown that diets with different concentrations of CP had similar excretions of fecal N but differed in urea N excretion (Colmenero and Broderick, 2006a; Edouard et al., 2016). Urea is the main N component in urine (i.e., 50–90%) and has the highest potential for N volatilization (Bussink and Oenema, 1998). Therefore, reducing N intake is the major strategy to reduce N excretion and counteract N pollution (Dijkstra et al., 2011; Hristov et al., 2011). Thus, N management is an important challenge in reducing environmental pollution without impairing animal performance. Nitrogen efficiency (**NE**; milk N secretion/dietary N intake) can be used as a tool for environmental and feeding management in dairy herds. In addition, it was suggested that improving NE may also enhance farm profits (Powell et al., 2010), which is advantageous for the producers.

Nitrogen efficiency has been shown to be lower under commercial conditions than under experimental conditions (Powell et al., 2010), suggesting that improvement in feeding practices can be achieved. In commercial settings, NE was around 25% and ranged between 17 and 35% (Jonker et al., 2002a; Powell et al., 2006; Gourley et al., 2012), whereas under experimentally

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controlled conditions mean NE was 30% and ranged between 18 and 42% (Hristov et al., 2004; Huhtanen and Hristov, 2009; Phuong et al., 2013). The principal dietary factor affecting NE is dietary CP concentration (Huhtanen and Hristov, 2009), where an increase in CP will negatively affect NE. Colmenero and Broderick (2006b) reported a reduction of 5.4 percentage units in NE by increasing CP in the diet from 16.5 to 19.4%. Another study also reported a reduction of NE from 27 to 24% by increasing CP in the diet from 16.7 to 18.4% (Broderick, 2003). In these studies, the modifications in dietary CP concentration did not affect milk production or the yields of milk fat and protein.

Another strategy to improve NE is to enhance animal performance by increasing dietary energy (Broderick, 2003; Rotz, 2004). In this regard, a major challenge of feeding protein, as shown by Rotz (2004) using a whole-farm modeling approach, is to provide the right amount with the proper degradation characteristics and to supply enough available energy to maximize animal performance while reducing N excretion at minimum cost. Therefore, we hypothesized that dairy herds could be characterized by their NE and that differences in animal performance and feeding strategies would exist among groups. Thus, the objective of this study was to identify the characteristics of commercial lactating herds with varying NE and assess its effect on farm profitability.

MATERIALS AND METHODS

Data Collection

All experimental procedures of this study were approved by the Animal Care Committee from Université Laval, Québec, Canada, following the guidelines of the Canadian Council on Animal Care (1993). One hundred dairy farms located in the province of Québec, Canada, were recruited. To be eligible for participation, farms had to be enrolled with the milking recording system of Valacta (Dairy Production Centre of Expertise, Québec and Atlantic Provinces, Sainte-Anne-de-Bellevue, QC, Canada). Herds comprised Holstein cows. Producers were contacted by phone, and their participation was voluntary. Herd size ranged from 16 to 113 cows in lactation. Among them, 98 herds were housed in tiestall barns, whereas the remaining 2 herds were kept in freestalls. All cows were milked twice a day. Farms were visited once at the times of feeding and milking to cover a production period of 24 h. The visit to each of the 100 herds was scheduled to coincide with a regular monthly DHI test and was completed between October 2014 and June 2015.

In the first morning of the visit, orts were discarded. Feeds offered (Table 1) were weighed and sampled for cows in lactation. When the farm feeding system was TMR, feeds offered were measured per group. When the farm feeding system was manual component feeding (**MCF**) or component feeding with an automatic feeding system (**AFS**), forages offered were measured per group, but concentrate feeds offered for each cow were measured individually. When forages were fed as bales of silage or hay, bales were weighed with an electronic scale (OCSB3 Compact Crane Scale, Anyload Transducer Co. Ltd., Burnaby, BC, Canada). For concentrate feeds, if they were fed manually, the quantities were weighed before they were offered to the cows. When an AFS was used on the farm, the quantities of feeds offered were recorded as programmed in the system. To ensure the accuracy of AFS measurements, a validation was performed by weighing once the amounts of feeds served, which were compared with the programmed quantity. When feeds were fed as TMR, the quantities offered were recorded from the scale of the mixing system. The amount of TMR offered to at least 10 cows was weighed for validation. Orts were weighed and sampled per group before or after the a.m. milking of the second day according to individual feeding management practices.

Samples of all individual dietary ingredients and TMR were taken and frozen at −20°C. Additional silage samples were taken and sent to the Valacta laboratory for determination of pH, NH_3-N, and organic acid profile by near-infrared spectroscopy.

The feedstuff samples were oven dried at 55°C for 48 h to determine DM, ground through a 1-mm sieve, and analyzed for nutrient composition by wet chemistry in a commercial laboratory (SGS Agrifood Laboratories, Guelph, ON, Canada) according to the following methods: CP (N × 6.25; method 990.03; AOAC International, 2005), soluble protein (Roe et al., 1990), ADF [Ankom, 2017b; solutions as in method 973.18; AOAC International, 2005], NDF [Ankom, 2017c; solutions as in Van Soest et al. (1991) with the inclusion of heat-stable α-amylase], acid detergent insoluble CP and neutral detergent insoluble CP (method 990.03; AOAC International, 2005), lignin (method 973.18D; AOAC International, 2000), crude fat (Ankom, 2009; AOCS, 2008), and starch (method 996.11; AOAC International, 2005). The NDF of orts were analyzed using the Ankom filter bag technique (Ankom, 2017a; solutions as in Van Soest et al., 1991).

During the p.m. and next a.m. milkings, milk yield from each cow was recorded and milk was sampled using inline milk meters. Samples were stored at 4°C with a preservative (2-bromo-2-nitropan-1,3-diol) and sent