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Precision diet formulation to improve performance and profitability across various climates: Modeling the implications of increasing the formulation frequency of dairy cattle diets

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ABSTRACT

The objective of this study was to use a precision nutrition model to simulate the relationship between diet formulation frequency and dairy cattle performance across various climates. Agricultural Modeling and Training Systems (AMTS) CattlePro diet-balancing software (Cornell Research Foundation, Ithaca, NY) was used to compare 3 diet formulation frequencies (weekly, monthly, or seasonal) and 3 levels of climate variability (hot, cold, or variable). Predicted daily milk yield (MY), metabolizable energy (ME) balance, and dry matter intake (DMI) were recorded for each frequency-variability combination. Economic analysis was conducted to calculate the predicted revenue over feed and labor costs. Diet formulation frequency affected ME balance and MY but did not affect DMI. Climate variability affected ME balance and DMI but not MY. The interaction between climate variability and formulation frequency did not affect ME balance, MY, or DMI. Formulating diets more frequently increased MY, DMI, and ME balance. Economic analysis showed that formulating diets weekly rather than seasonally could improve returns over variable costs by $25,000 per year for a moderate-sized (300-cow) operation. To achieve this increase in returns, an entire feeding system margin of error of <1% was required. Formulating monthly, rather than seasonally, may be a more feasible alternative as this requires a margin of error of only 2.5% for the entire feeding system. Feeding systems with a low margin of error must be developed to better take advantage of the benefits of precision nutrition.
Key words: precision feeding, dairy, climate variability, milk yield

INTRODUCTION

Precision dairy nutrition has been defined as the use of information technology to optimize economic, social, and environmental farm performance (Spilke and Fahr, 2003). Precision feeding optimizes these performance attributes by facilitating the economically and ecologically sound production of a quality milk product that is highly acceptable to the consumer (Spilke and Fahr, 2003). It is gaining interest as a robust management practice capable of increasing efficiency, reducing costs, improving product quality, minimizing environmental impact, and improving the health and well-being of dairy cattle (Bewley, 2010). Several studies have modeled the effect of precision nutrition on whole-farm nutrient balance (Wang et al., 2000b; Cerosaletti et al., 2004; Ghebremichael et al., 2007; Gehman, 2011). These models indicate that precision nutrition improves dairy productivity by meeting each individual animal's or pens of animals' nutrient requirements more accurately (Wang et al., 2000a; Cerosaletti et al., 2004; Gehman, 2011). On-farm studies have also shown the benefits of precision nutrition. Real-time monitoring of lactating cow feed intake can improve DMI (Halachmi et al., 1998), and on-farm implementation of feeding suggestions from a precision management model can improve milk yield and income over feed costs (Andre et al., 2007). These results indicate that precision feeding may be one method to concurrently improve nutrient-use efficiency and productivity.

To date, few studies have explored the robustness of precision nutrition strategies across variable climates. However, 2 major model systems in dairy nutrition have the capacity to specifically account for additional energy required under conditions of environmental stress (Fox and Tylutki, 1998; NRC, 2001; Fox et al., 2004). The influence of climate on dairy production is well documented (Blackshaw and Blackshaw, 1994; Collier et al., 2006; St-Pierre et al., 2003; West, 2003; Wheelock et al., 2010), and strong evidence indicates that climate variability is increasing (IPCC, 2007; McKibben, 2007; Nardone et al., 2010).

Therefore, the objective of this study was to use a precision nutrition model to simulate the effect of diet formulation frequency on the predicted milk yield (**MY**), DMI, and ME balance of a representative aver-

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age dairy cow under various climate conditions, and to assess the effect of diet formulation frequency and climate variability on returns over variable costs. We hypothesized that formulating diets more frequently would result in improved ME balance, increased MY, and improved profitability regardless of climate.

MATERIALS AND METHODS

This study utilized data from existing reports and databases to generate modeled outputs and required no Animal Care and Use Committee approval. Weather data sourced from National Climate Data Center (NCDC, 2010) were entered into the Agriculture Modeling and Training Systems (**AMTS**) CattlePro diet balancing software. Weather data representing a hot, humid year; a cold, windy year; and a highly variable year were entered on a weekly, monthly, and seasonal basis. Modeled MY, ME balance, and DMI were recorded and compared across weather scenarios and formulation frequencies using a fixed-effects ANOVA. Feed cost and milk price data were sourced from USDA-ERS (2012) and used with modeled MY and DMI to calculate income over feed and labor costs. Results were compared with previously published modeled and measured estimates of climate stress or precision feeding effects on dairy productivity and profitability. To account for variability in feed cost and milk price data, sensitivity analysis on the income over feed and labor cost calculation was conducted.

Generation of Performance Outputs

Diets were formulated and cattle performance simulated using AMTS CattlePro (AMTS, 2006). CattlePro calculations are based on the Cornell Net Carbohydrate and Protein System (**CNCPS**; AMTS, 2006). CattlePro was used because it specifically accounts for the influence of environment on nutrient requirements under a wide array of environmental conditions (Fox et al., 2004; Tylutki et al., 2008).

In this study, diets were formulated on a seasonal, monthly, and weekly basis for a lactating Holstein cow to test whether reformulating diets more frequently would increase milk production in an average animal. Nutritional requirements were generated for cows weighing 680 kg producing 36.5 kg/d of milk at 153 DIM, with a milk fat content of 3.8% and a milk protein content of 3.1%. A full list of input variables used to describe the cows and housing system is included in Table 1. The data describing cows were selected to best simulate an average animal on an operation at any given point during the year. Given the variability in production responses to nutritional modification across lactation and productivity level, it is important to note that these results are the mean predicted response of an average animal and should not be extrapolated to explain the responses of individual cows during different lactation stages or levels of productivity. This study aimed to simulate a freestall housing system; however, in many but not all freestall systems, wind speed (**WS**) may not have a significant influence upon animal nutrient requirements because of the presence of sheltered areas. In this study, we included WS without accounting for decreases due to sheltered areas or windbreaks. Attenuation of WS was not modeled in this study because insufficient data were available to develop a defendable numerical relationship between WS within a protected freestall system and outside WS. The study may overestimate negative implications of cold stress on dairy cattle in freestall systems and the results may be more applicable to a drylot or pasture-based system. That said, substantial proportions of US operations keep cows in an outside drylot (with or without freestalls; 27%) or allow access to pasture (49%) for some length of time during lactation (USDA-APHIS, 2007).

Feedstuff inputs for diet formulation were sourced from the feedbank in CattlePro (AMTS, 2006). Diets were formulated using an identical base composition (comprising steam-flaked corn grain, corn distillers grains, corn silage, soybean meal, grass hay, and alfalfa hay) with corn grain content varying to meet energy requirements as predicted by CattlePro. Dry hay rather than haycrop silage was selected as a feed in this study because its nutrient content was assumed to be more consistent due to the high variability of DM content in haycrop silage. Diet ingredient composition, ME, and MP values are shown in Table 2. Table 3 shows chemical composition of feedstuffs used. Environmental inputs required for CattlePro included previous and current values for daily temperature (**T**), WS, and rela-

Table 1. Cow and housing inputs used in diet formulation

Input	Value
Age (mo)	44.00
Days pregnant (d)	65
Days since calving (d)	188
Calving interval (mo)	14.00
Calf birth weight (kg)	44
Age at first calving (mo)	26.10
Milk production (kg/d)	36.50
Milk fat (%)	3.80
Milk true protein (%)	3.10
Milk lactose (%)	4.78
BCS	3.00
Housing system	Freestall
Hours standing	12
Number of position changes	9
Flat distance walked (m)	300
Sloped distance walked (m)	1