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Effect of Level of Metabolizable Protein on Milk Production and Nitrogen Utilization in Lactating Dairy Cows[1]

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ABSTRACT

The objective of this study was to investigate the effects of the level of metabolizable protein (MP) on milk production and nitrogen utilization in Chinese Holstein dairy cows. Forty multiparous dairy cows (body weight = 590 kg; days in milk = 135; average milk yield = 30.2 kg/d) were assigned to treatments randomly within groups based on days in milk and milk production. Animals were offered diets with different levels of MP: 8.3% (diet A), 8.9% (diet B), 9.7% (diet C), and 10.4% (diet D) of dry matter. The MP level in diet A was designed to meet the current Chinese National Station of Animal Production and Health guidelines, whereas that in diet D was based on the National Research Council (2001) model. The experiment lasted for 7 wk. Milk yield and milk composition (fat, protein, and lactose) were recorded, and urea nitrogen concentrations in serum, urine, and milk were measured during the experiment. Milk yield and milk protein percentage increased as the MP increased up to 9.7% of dry matter, and then leveled off. Concentrations of nitrogen in urine, serum, and milk increased linearly as the amount of MP was increased, indicating decreased efficiency of nitrogen utilization. Milk lactose percentage and total solids percentage showed no significant differences among the 4 diets. We concluded that the optimal dietary MP level was at 9.6% of dry matter for Chinese Holstein dairy cows producing 30 kg of milk per day.
Key words: metabolizable protein, milk production, nitrogen utilization, lactating cows

INTRODUCTION

The agricultural community is under strong pressure from the public to reduce avoidable losses of N all over the world. With increasing environmental constraints, research is being directed toward improving the efficiency of N utilization by lactating dairy cows while optimizing milk production and composition.

Recent studies have shown that altering the supply of RUP alone cannot explain variations in milk production responses (Santos et al., 1998; NRC, 2001). Together, these data clearly demonstrate that the supply of CP or RUP in dairy rations should no longer be used alone to estimate the protein delivered to animals. A more precise system of MP was used to supersede the use of the CP or RUP system (NRC, 2001). When the earlier data were reevaluated using this approach, it was clear that changes in milk production were related to the MP rather than to either CP or RUP (Metcalf et al., 1996; Wright et al., 1998).

Although the protein systems for dairy cattle in different feeding standards [Agricultural and Food Research Council (**AFRC**), 1993; NRC, 2001] are based on the requirements of rumen microbes and the host animals, comparison of these standards has revealed that the MP recommendation for midlactation cows producing up to 30 kg/d varies greatly among different recommendations. These differences are attributed to the requirements for maintenance and the efficiency of utilization of absorbed AA for milk protein synthesis. Furthermore, differences in requirements for maintenance between lactation and nonlactation or low and high dietary protein were not considered in the Chinese National Station of Animal Production and Health (**CNSAPH**) (2000) and AFRC (1993) .

The MP requirement may be met by providing both RDP and RUP. Rumen microbial protein, RUP, and endogenous protein contribute AA to the small intestines, with microbial protein accounting for the majority of the total AA flow (Clark et al., 1992; Santos and Huber, 1995). Therefore, supplementation of the MP is a direct way to increase the AA entering into the duodenum. However, overfeeding of protein may result in excessive excretion of urinary N, the most environmentally labile form of excreted N (Varel et al., 1999). There are reports that approximately 70% of the excreted N can be lost into the environment through volatilization, leaching, and runoff, contributing to environ-

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mental pollution (Tamminga, 1992; Van Horn et al., 1994; Huston et al., 1998).

The objective of this study was to determine the effects of the dietary MP level on milk production and on N utilization and excretion in Chinese Holstein dairy cows, especially in milk protein production efficiency in comparison with the NRC (2001) recommendations.

MATERIALS AND METHODS

Animals, Diets, and Experiment Design

Forty multiparous Chinese Holstein cows in midlactation [BW = 590 kg (SD 15); average DIM = 135 (SD 7), milk yield = 30.2 kg (SD 2.69)/d)] were used in a completely randomized block design. Animals were divided into 10 groups according to DIM and milk production and were assigned to treatments randomly within groups to evaluate the response to dietary MP. Cows were housed in a tie-stall barn and were fed and milked at 0600, 1430, and 2100 h. All animals had free access to drinking water. The experiment lasted for 7 wk from early April to the end of May 2005, following a week of adaptation to the diets.

Four diets (A, B, C, and D) were formulated to contain 4 levels of MP (8.2, 8.9, 9.7, and 10.3% of DM), with CP contents of 12, 13, 14, and 15% of DM, respectively. The content of NE_L was 1.4 Mcal/kg for all diets, with the ratio of concentrate to forage at 45:55 (DM basis), and alfalfa hay and corn silage were the main sources of forage. The ingredients and composition of the experimental diets are presented in Table 1. Diet A was designed to meet MP requirements for lactating cows producing 30 kg of milk according to the CNSAPH (2000), whereas the MP level in diet D was based on the NRC (2001) model. Diets B and C were formulated to contain midlevels of dietary MP. Feed was offered to result in 10% orts.

Table 1. Ingredients and composition of the experimental diets

Item	Diet A	Diet B	Diet C	Diet D
Ingredient, % of DM				
Alfalfa hay[1]	22	22	22	22
Corn silage[2]	33	33	33	33
Ground corn grain	27.6	24.5	21.3	17.0
Soybean meal, 42.5% CP	1.7	2.5	5.5	6.6
Cottonseed	2.7	3.0	2.7	2.6
Cottonseed meal	3.2	3.6	3.6	5.1
Wheat bran	3.4	3.7	3.4	3.0
Rapeseed meal	1.5	2.8	3.9	5.8
Dicalcium phosphate	1.3	1.3	1.0	1.3
Limestone	0.9	0.9	0.9	0.9
Sodium bicarbonate	0.7	0.7	0.7	0.7
Salt	1.0	1.0	1.0	1.0
Premix[3]	1.0	1.0	1.0	1.0
Composition				
DM, %	50.5	50.7	50.8	50.9
CP, % of DM	11.9	13.0	14.2	15.4
RUP,[4] % of DM	4.5	5.4	6.6	7.9
RDP,[4] % of DM	7.4	7.6	7.6	7.5
MP,[4] % of DM	8.3	8.9	9.7	10.4
NDF,[4] % of DM	41.0	41.5	41.8	42.0
NE_L,[4] Mcal/kg of DM	1.4	1.4	1.4	1.4

[1]Alfalfa hay contained 90% of DM, 18.4% CP, 10.9% RDP and 60.3% NDF, and 44.7% ADF on a DM basis.

[2]Corn silage contained 22.7% DM, 7% CP, 4.6% RDP, 67.2% NDF and 41.0% ADF on DM basis.

[3]Formulated to provide (per kg of DM) 1,000,000 IU of vitamin A, 200,000 IU of vitamin D, 1,250 IU of vitamin E, 14,000 mg of Zn, 100 mg of Se, 180 mg of I, 3,000 mg of Fe, 40 mg of Co, 3,000 mg of Mn, and 3,000 mg of Cu.

[4]Calculated based on individual feedstuffs in the Chinese National Station of Animal Production and Health (2000) guidelines.

Sampling, Measurement, and Analyses

Feeds offered to and refused by individual cows (3 for each treatment) were weighed for 2 consecutive days every second week throughout the trial. The forage and concentrates were sampled weekly. Ort samples were collected weekly and composited by animal (3 for each treatment) in proportion to the wet weight of orts from each specific day. All samples were immediately dried in a forced-air oven at 60°C for 48 h and stored in sealed plastic containers at room temperature until analyzed. In preparation for analyses, dried forages and concentrates were ground first through a 2-mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA), then through a 1-mm screen in a Cyclotec mill (Tecator 1093, Tecator, Hoganas, Sweden). Dry matter was determined by drying a subsample at 100°C for 24 h. All samples were analyzed for NDF (Van Soest et al., 1991) and total N (method 988.05; AOAC, 1990).

Milk sampling devices (Waikato Milking Systems NZ Ltd., Waikato, Hamilton, New Zealand) were attached to the milking machine to measure milk weight and collect samples. Milk production was recorded for all 3 milking times. Two 50-mL aliquots of milk were collected weekly at each milking, proportional to yield (4: 3: 3, composite). One aliquot containing Bronopol (milk preservative, D&F Control Systems, San Ramon, CA) was stored at 4°C for later analysis of fat, protein, and lactose by infrared analysis (Laporte and Paquin, 1999) with a 4-channel spectrophotometer (Milk-O-Scan, Foss Electric, Hillerød, Denmark). The second aliquot without Bronopol was stored at –20°C and thawed for analysis after the end of the experiment. The samples were deproteinized with 4 mL of cold TCA (25%), allowed to stand for 5 min, and then centrifuged at 3000 × *g* for 20 min at 4°C. The clear supernatant was pipetted carefully through the solidified fat layer and analyzed for MUN using the diacetyl monoxime-binding assay (Rahmatullah and Boyd, 1980).