# Varying Protein Content and Nitrogen Solubility for Pluriparous, Lactating Holstein Cows: Digestive Performance During Early Lactation[1]

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## ABSTRACT

Thirty-four pluriparous Holstein cows were used to examine effects of crude protein (15.3 vs. 13.6%, dry matter basis) and nitrogen solubility (39.7 vs. 47.9%) on digestibility, energy and protein balances, and related traits during early lactation. Cows were assigned randomly at parturition to treatments in a 2 × 2 factorial arrangement; measurements were during wk 6, 10, and 14 postpartum. Diets were protein supplements (varying in protein content and nitrogen solubility), low-protein concentrate, corn silage treated with urea at ensiling, and wilted grass silage fed individually for ad libitum intake.

Reducing nitrogen solubility of diet improved energy intake and productive energy factors but resulted in no significant increase of milk yield or body tissue balances, although body fat balance tended to be higher for low-solubility diets. There was no effect on overall partition of nitrogen in the body.

Digestibility of carbohydrates and protein was higher for 15.3 than for 13.6% crude protein diets, resulting in higher total digestible nutrients and digestible and metabolizable energy of dry matter. Raising crude protein in the ration decreased milk yield of cows in early lactation but generally increased body tissue balances. Concentrations of rumen ammonia and blood urea nitrogen were not influenced by nitrogen solubility; increasing dietary protein increased concentrations of both, although not enough to increase consumption of free water. Best digestive efficiency was for animals fed the ration of medium crude protein and low nitrogen solubility.

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## INTRODUCTION

Generally diets with nonprotein nitrogen (NPN) and high nitrogen solubility (NSOL) have not been recommended for high-producing cows in early lactation (8). Wohlt and Clark (35) concluded that, for maximum milk yield, high-producing dairy cows require a diet containing at least 13.5 to 14.5% crude protein (CP) in diet dry matter (DM) and that all supplemental CP should be preformed. Brown et al. (7) summarized 4839 28-d cow trials and found a curvilinear response of milk yield with maximum production occurring at 16% CP. Studies on responses of milk to rations containing more than 12 to 14% CP in diet DM are conflicting. In general, increasing dietary CP during early lactation has improved intake of energy and milk yield (10,11,13,27,36); when there was no response of intake, little or no effect on milk yield was observed (11,13,15, 29,32).

Percent NSOL of the diet has gained increasing emphasis as a factor in metabolism of CP and NPN in ruminants (2,6,25). Selection of feeds with low NSOL may lead to increased supply of undegraded protein to the intestines and to improved animal performance. Majdoub et al. (25) formulated four diets varying in CP (13 vs. 15%) and NSOL (22 vs. 42%) using natural feedstuffs. Solubility of nitrogen (N) had no effect on intake of DM (DMI), CP, or net energy for early (8 to 10 wk postpartum) lactation. Highest yield of milk (27.7 kg) was from the higher CP, low-NSOL diet. Other studies (16,19) have shown little or no response during early lactation from limiting NPN intake or NSOL. Holter et al. (21) found when NSOL was low (19 to 22%), milk yield increased with increasing CP up to 16%. When diets were of high NSOL (44 to 47%), there were no significant effects of increasing CP from 13.8% CP on milk yield or body protein balance. Our objective was to examine the effects of percentages of CP and NSOL in the diet and their interactions on digestibility, energy and protein balances, and related traits during early lactation.

## MATERIALS AND METHODS

Thirty-four pluriparous Holstein cows from (22) were selected to measure nutrient digestibility and N and energy balances during wk 6, 10, and 14 of lactation. Animals were in digestion stalls for 2 days adjustment period prior to measurements. Rumen fluid and blood were sampled just before feeding on the 2nd d of the adjustment period; this was followed by 6-d excreta collection and two consecutive 11-h methane ($CH_4$) and heat production measurements.

Ingredient composition of concentrates is presented in (22). All ration components were blended and fed twice daily as in (23) to provide at least 2.3 kg orts daily. Sodium bicarbonate (125 g/day) was top-dressed on silage during wk 1 to 8 postcalving except when cows were in the respiration chamber to avoid possible interference of carbon dioxide ($CO_2$) emission with measurement of respiratory exchange. During the collection period DM of silages and orts was determined daily using Koster Moisture Testers[4] to ensure the 63:37 DM ratio of corn and haycrop silages. Daily samples of orts and ration components were composited over the collection period and stored at 1°C until analyzed. Composites of low-protein grain and supplements were ground in a Wiley mill (1-mm), thoroughly mixed, subsampled, and analyzed for proximate nutrients (4), acid detergent fiber (ADF) (4), and combustible energy (Parr adiabatic oxygen bomb calorimeter). Silages and orts were dried in a convection oven at 55°C to 88 to 90% DM and then analyzed as for concentrates. Haycrop silage also was analyzed for acid detergent insoluble nitrogen (ADIN) (4). We determined NSOL for feeds using an extraction procedure described by (12) and modified by using phosphate and bicarbonate buffers.

Rumen fluid, obtained by stomach tube, was filtered through four layers of cheesecloth and analyzed for ammonia using an ammonia electrode.[5] Blood from the jugular vein was collected in 15-ml vacutainer tube, allowed to clot for 30 min in a waterbath at 30°C, and centrifuged[6] for 40 min at 3500 × *g*. Serum (3 ml) was removed and sent[7] for analysis of blood urea nitrogen (BUN). Rumen ammonia ($NH_3$) and BUN were measured once just before feeding, since treatment effects for these traits previously were similar at 0 vs. mean for 0, .5, 2, 4, 6, and 8 h postfeeding (21). Feces and urine were collected using mechanical separators and weighed daily; a 1% aliquot was taken each day and composited over the 6-d collection period. Urine was acidified with 100 ml HCl daily as produced to prevent loss of N. Feces and urine were analyzed for combustible energy, proximate nutrients (as appropriate), and N according to (4). Fecal N was measured in undried samples. Milk samples (1 ml/.45 kg of milk produced) were collected from each milking, composited over the collection period, and analyzed for fat (Babcock), solids-not-fat (Golding Bead Test), protein (Orange G Dye Binding), CP (Kjeldahl, N × 6.38), and combustible energy.

Following excreta collection, cows were placed in an open-circuit, indirect respiration calorimeter to measure heat and $CH_4$ production for two consecutive 11-h periods. Samples of composite chamber air were analyzed for $CO_2$, $CH_4$, and $O_2$ concentrations.[8] Heat production data were adjusted to standard physical activity (50% time spent standing, one position change per hour) as described by (9).

[4] Koster Crop Tester, 4716 Warrensville Center Road, North Randall, OH.

[5] Orion Model 407A meter with 95-10 electrode.

[6] IECV Model PR6000.

[7] New England Clinical Laboratories, Inc., Tilton, NH 03276.

[8] Beckman analyzers: infrared Model IR 215, infrared Model 215A and Model F3, respectively.