

Effects of diet protein concentration on digestion and N balance of dairy cows over 3 lactations

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Introduction

Reduced diet crude protein (CP) concentration consistently increases diet N use efficiency (NUE; milk N/N intake), but often at the expense of dry matter intake (DMI) and milk yield. Our objective was to measure the effect of reductions in diet CP level on digestion and N utilization in lactating dairy cows. Measurements were made at 3 stages of 3 lactations.

Materials and Methods

- Holstein heifers (n=215) were assigned to one of 3 total mixed rations (TMRs) at first calving in a randomized block experiment (Reynolds et al., 2016).
- Total mixed ration diets were formulated to contain 14, 16, or 18% CP and provide metabolizable protein below (90%), at (100%), or above (104%) estimated requirements, respectively. Treatment diets were fed from 7 days in milk to dry-off for 3 full lactations.
- During each lactation, diet digestion and N balance were measured using 4 cows per treatment at 6, 20 and 34 weeks postpartum using 5-d total collection of faeces and urine.
- Measurements for each lactation (n = 12 per treatment) were analyzed for effects of diet, week, and their interaction using Mixed Models.

Table 1. Diet digestion and N utilization in first lactation dairy cows.

	Diet Crude Protein				P < ¹			
	14%	16%	18%	SEM	Diet	Week	Inter	Linear
DMI, kg/d	18.1	19.9	19.9	0.61	0.099	0.001	0.015	0.064
DM Digestion, g/kg	708	712	724	9.4	0.498	0.426	0.236	0.264
Milk yield, kg/d	25.1	30.3	27.5	1.57	0.118	0.027	0.198	0.309
Milk urea, g/kg	169	256	312	26.6	0.013	0.005	0.515	0.005
N intake, g/d	410	506	562	14.4	0.001	0.009	0.215	0.001
Faecal N, g/d	163	190	188	8.1	0.075	0.241	0.886	0.057
Faecal N/N intake	0.40	0.38	0.34	0.019	0.112	0.678	0.978	0.044
Digested N, g/d	248	316	374	17.5	0.003	0.106	0.505	0.001
Milk N, g/d	134	155	152	6.6	0.105	0.349	0.129	0.087
Urine N, g/d	95	146	182	9.9	0.001	0.001	0.122	0.001
Urine urea N, g/d	69	108	146	11.1	0.003	0.001	0.135	0.001
Urine N/Manure N	0.37	0.43	0.49	0.024	0.017	0.139	0.747	0.006
Tissue N, g/d	18.1	15.1	40.2	15.80	0.495	0.584	0.925	0.345
NUE	0.33	0.31	0.27	0.011	0.012	0.129	0.594	0.004

¹Probability for effects of diet crude protein (%), week of lactation, their interaction (Inter) or the linear effect of diet crude protein.

Results

- Overall, DMI and milk yield were not affected by diet, but milk yield tended to be lower for the 14% CP diet in parity 1 and 2 cows (Table 1 and 2).
- Nitrogen intake and milk urea N concentration increased linearly, and NUE (milk N/N intake) decreased linearly, with increasing diet CP concentration.
- Digestibility of DM increased with increasing diet CP concentration for 2nd and 3rd parity cows (Tables 2 and 3), but not primiparous cows with lower DMI.
- Faecal N as a proportion of intake N decreased linearly, whilst total N digested increased linearly, with increasing diet CP concentration.

Table 2. Diet digestion and N utilization in second lactation dairy cows.

	Diet Crude Protein				P < ¹			
	14%	16%	18%	SEM	Diet	Week	Inter	Linear
DMI, kg/d	21.2	22.8	20.8	0.88	0.285	0.174	0.384	0.769
DM Digestion, g/kg	697	705	717	5.9	0.088	0.196	0.885	0.032
Milk yield, kg/d	30.4	34.7	34.6	1.58	0.130	0.001	0.888	0.086
Milk urea, mg/L	177	254	335	15.2	0.001	0.439	0.074	0.001
N intake, g/d	487	587	624	26.8	0.014	0.199	0.113	0.006
Faecal N, g/d	177	204	188	12.2	0.342	0.643	0.279	0.548
Faecal N/N intake	0.36	0.37	0.30	0.009	0.002	0.765	0.309	0.001
Digested N, g/d	309	383	436	16.1	0.001	0.189	0.110	0.001
Milk N, g/d	161	177	172	10.6	0.567	0.027	0.888	0.469
Urine N, g/d	118	141	170	13.6	0.066	0.030	0.265	0.023
Urine urea N, g/d	82	118	135	13.4	0.047	0.044	0.604	0.018
Urine N/Manure N	0.39	0.41	0.47	0.025	0.120	0.098	0.706	0.054
Tissue N, g/d	31.1	65.1	97.4	18.77	0.091	0.018	0.085	0.033
NUE	0.33	0.30	0.27	0.014	0.048	0.010	0.664	0.017

¹Probability for effects of diet crude protein (%), week of lactation, their interaction (Inter) or the linear effect of diet crude protein.

Table 3. Diet digestion and N utilization in third lactation dairy cows.

	Diet Crude Protein				P < ¹			
	14%	16%	18%	SEM	Diet	Week	Inter	Linear
DMI, kg/d	21.0	23.5	22.9	1.05	0.254	0.003	0.064	0.220
DM Digestion, g/kg	696	714	715	5.5	0.071	0.127	0.731	0.042
Milk yield, kg/d	35.0	40.8	39.0	2.73	0.347	0.001	0.907	0.328
Milk urea, mg/L	190	261	304	7.0	0.001	0.076	0.880	0.001
N intake, g/d	486	612	673	32.9	0.009	0.004	0.123	0.003
Faecal N, g/d	176	211	208	13.9	0.184	0.401	0.208	0.129
Faecal N/N intake	0.36	0.35	0.31	0.0185	0.199	0.450	0.926	0.085
Digested N, g/d	310	401	465	23.8	0.004	0.021	0.700	0.001
Milk N, g/d ²	174	212	183	11.3	0.100	0.001	0.871	0.567
Urine N, g/d	128	192	221	18.6	0.016	0.075	0.689	0.006
Urine urea N, g/d	89	147	180	17.2	0.014	0.015	0.687	0.005
Urine N/Manure N	0.41	0.47	0.51	0.023	0.052	0.066	0.315	0.019
Tissue N, g/d	9.1	-2.9	61.6	17.25	0.045	0.677	0.997	0.050
NUE	0.36	0.35	0.28	0.012	0.003	0.001	0.309	0.002

¹Probability for effects of diet crude protein (%), week of lactation, their interaction (Inter) or the linear effect of diet crude protein. ²Quadratic effect of diet crude protein, P < 0.05

- As N intake increased with increasing diet CP concentration, amounts of N digested, excreted in urine, and excreted in urine as urea increased linearly, regardless of parity.
- Body tissue N retention also increased with increased N intake in second and third parity cows.
- Urine N as a proportion of manure N, and urine N as a proportion of intake N, both increased linearly with increasing diet CP concentration, but faecal N output was not affected by diet CP concentration.

Conclusions

- Decreasing N intake through reduced diet CP concentration was associated with improved NUE and reduced urine N, urinary urea N, and total N excretion in manure.

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