Impact of Physically Effective Fiber on Chewing, Nitrogen Balance, and Performance of Lactating Cows

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Hypothesis

Increasing physically effective neutral detergent fiber (peNDF) concentration of a total mixed ration (TMR) quadratically affects feed intake, chewing time, rumen microbial protein synthesis (MPS), and performance of dairy cows, which will alter their partitioning in nitrogen (N) excretion.

Figure 1. Experimental Holstein dairy cows at Les Cedres research station in INRAE Site Theix.

Conclusions

- The quadratic effects of increasing peNDF concentration on tested variables was confirmed.
- Increasing the peNDF concentration results in a greater proportion of ingested N being secreted via milk and a lower proportion excreted via urine.
- In the long-term, increasing the peNDF concentration may also provide economic and environmental benefits.

Materials and Methods

- Four lactating Holstein cows assigned to a 4 x 4 Latin Square (13d adaptation, 8d sampling).
- Diet: corn silage, grass haylage and hay, barley straw, concentrate and mineral mixtures, soybean and corn grain meal.
- Restrictive feeding: 95% of dry matter intake during adaptation was fed to cows during sampling.
- Concentration of peNDF was adjusted by TMR mixing time: 15, 30, 45, and 60 min.
- Measured variables: peNDF (Penn State Particle Separator), feed intake and digestibility (titanium dioxide), chewing behavior (Rumi Watch, Liestal Switzerland), MPS (via purine derivatives in urine sport samples), and milk performance.
- Statistical analysis: Mixed-model using SAS 9.4 with peNDF concentration and period as main effects, days in milk as covariable, and animal as random factor; tested for linear and quadratic contrasts.

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Results

Table 1. Physically effective neutral detergent fiber (peNDF) concentration and mean particle size of diets differing in mixing time (least square means, n = 4).

Variable	Mixing time (min)				SEM	Contrast	
	60	45	30	15		Linear	Quadratic
peNDF$_{>8.0}$[1] (g/kg of dry matter)	202	208	221	238	4.8	*<0.01*	*ns*
peNDF$_{>4.0}$[2] (g/kg of dry matter)	283	292	309	323	5.1	*<0.01*	*ns*
Geometric mean of particles (mm)	7.3	7.6	8.2	9.0	0.18	*<0.01*	*<0.01*

[1]peNDF$_{>8.0}$ = peNDF includes particles over 8 mm. [2]peNDF$_{>4.0}$ = peNDF includes particles over 4 mm.
ns = not significant if $P>0.05$, SEM = standard error of means.

Table 2. Estimated parameters of dairy cows fed diets differing in mixing time (least square means, n = 3 for 30 min and n = 4 for the rest).

Variable	Mixing time (min)				SEM	Contrast	
	60	45	30	15		Linear	Quadratic
DMI (kg/d)	21.9	22.1	22.5	20.2	1.45	*0.02*	*0.01*
NI (g/d)							
aOMd (g/100 g OM)	65.8	67.4	66.9	64.2	4.37	*ns*	*0.06*
Milk yield (kg/d)	27.2	26.7	25.8	27.2	1.90	*ns*	*ns*
Eating activity							
min/d	369	382	410	347	9.5	*ns*	*0.01*
min/kg DMI d^{-1}	17	17	18	18	0.4	*ns*	*ns*
Rumination							
min/d	551	565	568	557	9.1	*ns*	*ns*
min/kg DMI d^{-1}	25	26	25	28	0.5	*0.01*	*0.08*
MPS (g N/d)	373	428	388	279	35.5	*0.08*	*0.02*
Milk N (g/100 g NI)	29.3	28.6	27.5	31.3	2.01	*ns*	*<0.01*
Urinary N (g/100 g NI)	27.4	30.8	29.4	23.8	2.31	*0.04*	*<0.01*
Fecal N (g/100 g NI)	42.9	40.2	42.4	44.0	2.94	*ns*	*ns*

aOMd = apparent total tract digestibility of OM, DMI = dry matter intake, MPS = microbial protein synthesis, N = nitrogen, NI = N intake, *ns* = not significant if $P>0.05$, OM = organic matter, SEM = standard error of means.

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