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Exploring the relationship between physically effective and undigested fiber

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Recent research at Miner Institute has focused on the relationship between undigested and physically effective NDF (abbreviated as uNDF and peNDF). Physically effective NDF is commonly measured using the 4-mm screen in the Penn State Particle Separator and uNDF is measured as the undigested NDF following 240 hours of in vitro fermentation. Both of these measures are highly useful in the field because they allow us to do a much better job of predicting the cow's response to NDF. How dietary fiber particle size and digestibility interact to affect the chewing, intake, and productive responses of the cow is a hot topic among nutritionists. We aimed to answer these questions with our research:

1 Are there optimal peNDF concentrations as uNDF240 varies in the diet?

2 Can we adjust for a lack of peNDF by adding more uNDF240 in the diet?

3 If forage uNDF240 is high, can we compensate by chopping the forage finer?

TABLE 1
Ingredients used to adjust uNDF240 and peNDF in the ration

Ingredients, % of ration dry matter (DM)	Low uNDF240		High uNDF240	
	Low peNDF	High peNDF	Low peNDF	High peNDF
Corn silage	34.7	34.7	34.7	34.7
Chopped straw	1.6	1.6	1.6	1.6
Timothy hay – short	10.5	––	24.2	––
Timothy hay – long	––	10.5	––	24.2
Beet pulp	12.9	12.9	0.4	0.4
Grain mix	40.3	40.3	39.2	39.2
Forage % in the diet	46.8	46.8	60.5	60.5

Some nutritionists have questioned whether particle size is actually that important if we truly understand fiber digestibility (i.e., uNDF240, fast- and slow-fermenting NDF). Our work indicates that particle size, measured as peNDF, is important – just maybe not for the reasons we have always assumed, such as rumination. In fact, forage particle size seems to influence eating time more than ruminating time, which has important consequences for the cow's time budget and feedbunk management.

THE MINER PENDF AND UNDF240 STUDY

We evaluated the effect of feeding lower (8.9 percent of ration dry matter) and higher (11.5 percent of ration dry matter) dietary uNDF240 with either low or high peNDF. The diets contained approximately 35 percent corn silage, 1.6 percent chopped wheat straw, and chopped timothy hay with either a lower or higher physical effectiveness factor (pef). A Haybuster with its hammer mill chopping action created the two particle sizes of dry hay. The lower uNDF240 diets contained about 47 percent forage and the higher uNDF240 diets contained about 60 percent forage on a dry basis. The main dietary ingredients are

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shown in Table 1.

Table 2 summarizes the main fiber fractions in these four diets. In addition to the uNDF240 and peNDF, we have reported a new measure - peuNDF240 - which was calculated as pef x uNDF240. Note that the low uNDF240, high peNDF diet and the high uNDF240, low peNDF diets, although differing in uNDF240 and peNDF, contain the same peuNDF240 value. Considering the effects of particle size and uNDF240 together (as with peuNDF240) helps to explain cow productive responses as shown in Table 3.

The "bookend" diets that contained the extremes in either uNDF240 or peNDF (i.e., low uNDF240 and peNDF versus high uNDF240 and peNDF) consistently and predictably differed in DMI, milk yield and composition, and chewing behavior. The two intermediate diets that contained either low uNDF240 and high peNDF or high uNDF240 and low peNDF resulted in similar DMI and energy-corrected milk. It is interesting and important to note that that cows had similar energy-corrected milk production regardless of whether the diet was higher in uNDF240 but chopped more finely, or lower in uNDF, but with a coarser particle size.

Cows on the low uNDF240, low peNDF treatment spent roughly 45 minutes less each day at the bunk eating – while eating over five lb/day more of total mixed ration. The difference in eating time was driven by the time it takes the cow to reduce the TMR particle size when she consumes it. Cows fed these types of silage-based diets tend to chew TMR to a common particle size before swallowing, therefore rumination time will be largely unaffected. Excessive time spent at the bunk chewing feed in order to swallow it needs to be avoided since cows should only spend about three to five hours per day eating to have natural feeding behavior.

TABLE 2

Fiber characteristics of the diets

Analyses	Low uNDF240		High uNDF240	
	Low peNDF	High peNDF	Low peNDF	High peNDF
aNDFom, % of DM	33.1	33.3	35.7	36.1
uNDF240om, % of DM	8.9	8.9	11.5	11.5
peNDF, % of DM	20.1	21.8	18.6	21.9
peuNDF240, % of DM	5.4	5.9	5.9	7.1

TABLE 3

Intake and milk responses to dietary uNDF240 and peNDF

Item	Low uNDF240		High uNDF240	
	Low peNDF	High peNDF	Low peNDF	High peNDF
DMI, lb/day	60.6^{a}	60.2^{a}	60.4^{a}	54.9^{b}
ECM, lb/day	103.6^{a}	100.8^{ab}	102.3^{ab}	98.3^{b}
Eating time, min/day	255.4^{b}	262.5^{b}	279.1^{ab}	300.3^{a}
Rumination time, min/day	523.2	526.5	531.8	544.5

^{ab}Means with different superscripts differ ($P < 0.05$).

THE BOTTOM LINE

Physically effective uNDF240 (pef x uNDF240) appears to be a useful concept when formulating diets. We were able to elicit the same response by the cow whether we had lower uNDF240 in the diet chopped more coarsely, or whether we had higher uNDF240, but chopped more finely. If future research confirms this response across a wider range of diets, then when forage fiber digestibility is lower than desired, a finer forage chop length should enhance feed intake and energy-corrected production. ▮

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