Feed Management

A Key Ingredient in Livestock and Poultry Nutrient Management

Effective Fiber for Dairy Cows

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Disclaimer

This Feed Management Education Project was funded by the USDA NRCS CIG program. Additional information can be found at http://www.puyallup.wsu.edu/dairy/joeharrison/publications.asp
This project is affiliated with the LPELC http://lpe.unl.edu.

United States Department of Agriculture

NRCS Natural Resources Conservation Service

Introduction

This fact sheet has been developed to support the implementation of the Natural Resources Conservation Service Feed Management 592 Practice Standard. The Feed Management 592 Practice Standard was adopted by NRCS in 2003 as another tool to assist with addressing resource concerns on livestock and poultry operations. Feed management can assist with reducing the import of nutrients to the farm and reduce the excretion of nutrients in manure.

With the aim of maintaining normal ruminal pH, fiber digestion and milk fat test and preventing acute and sub-acute ruminal acidosis (SARA) and displaced abomasums (LDA), dairy cattle diets can be formulated or evaluated for chemical fiber (NRC, 2001) and effective fiber (Armentano and Pereira, 1997; Mertens, 1997; NRC, 2001) minimums and non-fiber carbohydrate (NFC) maximums (Nocek, 1997; NRC, 2001).
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Fiber and Non-Fiber Carbohydrates

Unlike other nutrients, such as protein and calcium, where requirements are provided in grams per cow per day for specific body weight and milk production levels, fiber "requirements" are merely minimum guidelines aimed at maintaining normal ruminal pH, fiber digestion and milk fat test and preventing SARA and LDA (NRC, 2001). NRC (2001) guidelines for minimum NDF from forage, minimum total diet NDF, and maximum diet NFC are presented in Table 1. Remember that these are fiber minimums and NFC maximums, and not recommended formulation targets for all situations.

Table 1 applies to diets containing ground corn as the primary starch source fed as TMR of adequate particle size, and assumes good feed delivery and bunk management practices.

Greater formulation safety margins (i.e higher NDF from forage and total NDF minimums and lower NFC maximums) should be used in herds without TMR feeding or with inadequate TMR particle size, highly rumen fermentable starch sources (i.e. steam-flaked corn or high moisture corn versus dry corn), and (or) poor feed delivery and bunk management practices (Refer to Table 2). Adequate TMR particle size means having at least 8% to 10% retained on the top screen of the Penn State-Nasco shaker box with less than 50% found on the bottom pan (as-fed basis; two screens plus pan system). If particles on the top screen come primarily from dry hay or straw rather than silage, then a TMR with 6% (as-fed basis) residing on the top screen may be adequate.

Low forage inventories and high relative costs of fiber and other nutrients from purchased forages versus purchased high-fiber by-products may create the need or desire to feed minimum forage diets. Diets with less than 19% NDF from forage should contain high-fiber by-products to increase total diet NDF and reduce diet NFC (Refer to Table 1). Selected high-fiber by-products and their respective NDF and NFC concentrations are presented in Table 3 for comparison with common forages and grains. In general, replacing grains with high-fiber by-products has the effect of raising total diet NDF and reducing diet NFC. This practice is positive in low forage diets, as it aids in meeting the total diet NDF and NFC recommendations.

Effective Fiber

The NDF in high-fiber byproducts is not as effective as the NDF from forage for maintaining normal milk fat test (Armentano and Pereira, 1997). The exception to this is whole cottonseed where the NDF effectiveness factor relative to forage NDF is near 100% (Clark and Armentano, 1993). This is one of the main reasons why whole cottonseed has become such a common feed ingredient in low forage diets. The 15% NDF from forage row in Table 1 is not recommended, because a depression in milk fat test would be expected. Assuming an average NDF concentration for dietary forages of 45%, diet formulation for 19% or 16% NDF from forage would result in diets containing 42% or 35% forage (DM basis), respectively (Refer to Table 4). Again, greater formulation safety margins (i.e higher NDF from forage and total NDF minimums and lower NFC maximums) should be used in herds without TMR feeding or with inadequate TMR particle size, highly rumen fermentable starch sources (i.e. steam-flaked corn or high moisture corn versus dry corn), and (or) poor feed delivery and bunk management practices (Refer to Table 2).

Mertens (1997) defined effective NDF (eNDF) as the overall effectiveness of NDF for maintaining milk fat test, and physically-effective NDF (peNDF) as the specific effectiveness of NDF for stimulating chewing activity in relationship to particle size. A recommendation for peNDF of 22% of ration DM to maintain an average ruminal pH of 6.0 and 20% of ration DM to maintain milk fat test above 3.4% was provided. Mertens (1997) further proposed determining the peNDF (% of DM) of feeds by multiplying NDF concentration by the proportion of particles retained on a 1.18-mm sieve or peNDF effectiveness factor. Percentages of particles retained on a 1.18-mm sieve (peNDF effectiveness factors) reported for soybean hulls, brewers grains, corn silage, legume silage-fine chop, legume silage-coarse chop, legume hay, and grass hay were 3%, 18%, 81%, 67%, 82%, 92%, and 98%, respectively. Mertens (personal communication) suggests a peNDF effectiveness factor for whole cottonseed of 90% when fed with hay or coarse-chopped silages (adequate ruminal mat formation) and 40% when fed with fine-chopped silages (inadequate ruminal mat formation). The need to analyze individual feeds for the proportion of particles retained on a 1.18-mm sieve to determine peNDF effectiveness factors may be limiting the application of this system in the field, but this could be overcome in the future as particle size analysis becomes standardized and more common in commercial testing labs.

Presented in Table 5 are example calculations of forage replacement values for alternative roughage sources and high-fiber by-products. The feeding of 5 lb./cow/day DM from coarse-chopped hay can replace 5.5 to 7.0 lb./cow/day of haylage DM. In theory, coarse-chopped straw could replace up to 10.5 lb. of haylage DM. But, in practice straw is usually limited to 2 to 4 lb./cow/day for milking cows to formulate diets of sufficient energy density resulting in a potential haylage DM replacement of 4 to 8 lb./cow/day. Feeding 5 lb./cow/day DM from high-fiber by-products replaces only 2.0/cow/day haylage DM on average, except for whole cottonseed and cottonseed hulls with haylage replacement values of 6 and 10 lb./cow/day DM, respectively, at 5 lb./cow/day DM feeding rates. High forage replacement with cottonseed hulls should coincide with the feeding of coarse-chopped dry hay to provide adequate rumen mat formation.

Suggested feeding limits for selected high-fiber byproducts are presented in Table 6 (Adapted from Howard, 1988). Actual amounts fed should be determined by formulation of diets for requirements and limits for nutrients, such as CP, RUP, RDP, NDF, NFC, fat and P, especially when multiple high-fiber by-products are used in the same diet.

There are numerous errors in feed delivery and bunk management that can occur on commercial dairies (i.e. errors in feed sampling and analyses, errors in ingredient DM adjustments, failure to evaluate forage and TMR particle size, failure to evaluate grain moisture content and degree of processing, errors in ingredient feeding rates, mixing errors including over-mixing that causes particle size reduction, and feed sorting). Close attention should be paid to proper feed delivery and bunk management practices, especially when implementing diet changes aimed at feeding minimum forage. Factors that may make TMR prone to sorting include: DM content and particle size of forage and mix, variation in bulk density of feed ingredients, large pieces of cobs and husks in the corn silage, amount and quality of hay added to mix, improper sequencing of ingredients into the mixer, frequency of feeding and push-up, availability of bunk space, and bunk access time. An on-farm evaluation of sorting should include particle size determination of TMR, bunk mix, and refusals. If sorting is determined to be a problem, then one or more of the following options may need to be considered: feeding smaller amounts of TMR more frequently, adding less hay to the mix, processing hay finer, using higher quality hay, using hay that is more pliable, processing corn silage, addition of water to dry TMR, and addition of a liquid feed supplement to TMR. Greater formulation safety margins (i.e higher NDF from forage, total NDF, and effective NDF minimums and lower NFC maximums) may be necessary in herds with poor bunk management practices.

Table 1. Recommended minimum concentrations (% of DM) of NDF from forage and total diet NDF and recommended maximum concentrations (% of DM) of NFC for diets containing ground corn as primary starch source fed as TMR of adequate particle size (NRC, 2001).

Minimum NDF from forage	**Minimum NDF in Diet**	**Maximum NFC in diet**[1]
19%	25%	44%
18%	27%	42%
17%	29%	40%
16%	31%	38%
15%[2]	33%	36%

[1]Non-fiber carbohydrate = 100 – (%NDF – NDFIP + % CP + %Fat + %ash).

[2]Not recommended because of depression of milk fat test.

Table 2. Recommended minimum concentrations (% of DM) of NDF from forage and total diet NDF and recommended maximum concentrations (% of DM) of NFC for diets of lactating dairy cows fed in herds without TMR feeding or with inadequate TMR particle size, highly rumen fermentable starch sources (i.e. steam-flaked corn or high moisture corn versus dry corn), and (or) poor feed delivery and bunk management practices (adapted from NRC, 2001).

Minimum NDF from forage	**Minimum NDF in Diet**	**Maximum NFC in diet**[1]
19%	--	--
18%	--	--
--	29%	40%
--	31%	38%
--	33%	36%

[1]Non-fiber carbohydrate = 100 – (%NDF – NDFIP + % CP + %Fat + %ash).

Table 3. Tabular mean NDF and NFC concentrations (% of DM; NRC, 2001) for selected forages, grains, and high-fiber byproducts.

Ingredient	**NDF%**	**NFC%**[1]
Alfalfa	35-50	20-30
Grasses	50-65	10-20
Corn Silage	45-55	30-40
Shelled Corn	9.5	75.4
Ear Corn	21.5	64.3
Alfalfa Meal	41.6	28.8
Beet Pulp	45.8	35.8
Brewers Grains	47.4	13.9
Canola Meal	29.8	25.9
Citrus Pulp	24.2	56.8
Corn Gluten Feed	35.5	30.4
Cottonseed Hulls	85.0	3.5
Cottonseed Meal	30.8	19.0
Distillers Grains	38.8	16.3
Hominy	21.1	60.1
Linseed Meal	36.1	31.0
Malt Sprouts	47.0	23.2
Soybean Hulls	60.3	18.3
Sunflower Meal	40.3	27.7
Wheat Middlings	36.7	35.3
Whole Cottonseed	50.3	2.7

[1]Non-fiber carbohydrate = 100 – (%NDF – NDFIP + % CP + %Fat + %ash).

Table 4. Calculated forage concentration in the diet to meet minimum NDF from forage guidelines with forage of varying NDF concentration (DM basis).

Minimum NDF from forage	**40% NDF forage**	**45% NDF forage**	**50% NDF forage**
19%	48%[1]	42%	38%
18%	45%	40%	36%
17%	43%	38%	34%
16%	40%	35%	32%

[1]Dietary forage concentration as % of DM.

Table 5. Example calculations of forage replacement values for alternative roughage sources and high-fiber byproducts.

Ingredient	**NDF[1] % of DM**	**pef[2] % of NDF**	**peNDF[3] % of DM**	**Replaces per lb. DM[4]**	**Replaces per 5 lb. DM**
Replaced Haylage					
Medium Chop Length	45	85	38.3	--	--
Replacement Feeds					
Coarse Chopped Straw	73.0	110	80.3	2.1	10.5[5]
Coarse Chopped Grass Hay	55	95	52.3	1.4	7.0
Coarse Chopped Alfalfa Hay	45	90	40.5	1.1	5.5
Alfalfa Meal	41.6	40	16.6	0.4	2.0
Beet Pulp	45.8	30	13.7	0.4	2.0
Brewers Grains	47.4	40	19.0	0.5	2.5
Canola Meal	29.8	40	11.9	0.3	1.5
Citrus Pulp	24.2	30	7.3	0.2	1.0
Corn Gluten Feed	35.5	40	14.2	0.4	2.0
Cottonseed Hulls	85.0	90	76.5	2.0	10.0[6]
Cottonseed Meal	30.8	40	12.3	0.3	1.5
Distillers Grains	38.8	40	15.5	0.4	2.0[7]
Hominy	21.1	40	8.4	0.2	1.0
Linseed Meal	36.1	40	14.4	0.4	2.0
Malt Sprouts	47.0	40	18.8	0.5	2.5
Soybean Hulls	60.3	30	18.1	0.5	2.5
Sunflower Meal	40.3	40	16.1	0.4	2.0
Wheat Middlings	36.7	40	14.7	0.4	2.0
Whole Cottonseed	50.3	90	45.3	1.2	6.0[7]

[1]Adapted from NRC (2001).
[2]Physical effectiveness factors (% of NDF) adapted from Mertens (2002).
[3]Physically effective NDF (% of DM) calculated as NDF*(pef/100).
[4]Replacment value of feeds per lb. of DM for example haylage calculated as peNDF replacement feed divided by peNDF of haylage to be replaced.
[5]Straw usually limited to 2-4 lb./cow/day for milking cows to formulate diets of sufficient energy density.
[6]High forage replacement with cottonseed hulls should coincide with the feeding of coarse-chopped dry hay to provide adequate rumen mat formation. Actual feeding amount should be determined by dietary NDF and NFC guidelines provided in Table 1.
[7]Actual feeding amounts may be limited ingredient fat content

Table 6. Suggested feeding limits for selected high-fiber byproducts[1].

Ingredient	Suggested Limits lb. DM per cow per day[2]
Alfalfa Meal	5 - 10
Beet Pulp	8 - 12
Brewers Grains	5 - 10
Canola Meal	5 - 10
Citrus Pulp	5 - 10
Corn Gluten Feed	10 - 15
Cottonseed Hulls	5 - 10
Cottonseed Meal	5 - 10
Distillers Grains	5 - 10
Hominy	10 - 15
Linseed Meal	5 - 10
Malt Sprouts	5 - 10
Soybean Hulls	8 - 12
Sunflower Meal	5 - 10
Wheat Middlings	8 - 12
Whole Cottonseed	5 - 8

[1]Adapted from Howard (1988).
[2]Actual amounts fed should be determined by formulation of diets for requirements and limits for nutrients, such as CP, RUP, RDP, NDF, NFC, fat and P, especially when multiple high-fiber byproducts are used in the same diet.

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