Within Farm Variation in Nutrient Composition of Feeds

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Summary

Estimates of the amount of variation (i.e., standard deviations and ranges) in nutrient composition of common feeds are readily available from some national feed testing labs; however, estimates of variation on feeds within a farm are needed to determine appropriate feed sampling and ration re-formulation schedules. We conducted a large national survey to determine within farm variation for some common feeds. On average, within farm variation for crude protein **(CP)** and neutral detergent fiber **(NDF)** was 2 or 3 times less than variation in the national population. Within a farm, substantial day-to-day variation in dry matter **(DM)**, NDF, CP, and starch was observed for corn silage and haycrop silage, indicating that samples should be taken over several days and those results averaged for diet formulation purposes. In some cases, day-to-day variation was as great as month-to-month variation. The concentrations of NDF, but not CP, in high moisture corn, distillers grains, and brewers grains varied almost as much as NDF concentrations in some forages, indicating that these feeds should be sampled on a regular basis.

Introduction

Unquestionably, the nutrient composition of all feeds varies, which means that the composition of the rations fed to cows also vary. Although variation in nutrient composition is a well-accepted fact of life, this variation has not been extensively quantified, and the effects of variation on cows have not been studied. A group of researchers and Extension specialists at The Ohio State University, with the help of collaborating nutritionists and dairy farmers, are working on a large project designed to: 1) Determine the variation in nutrient composition of common feeds on commercial dairy farms; 2) Determine how variation in ingredients affects variation in nutrient composition of TMR on commercial dairy farms; 3) Partition sources of variation (e.g., lab, sampling, and 'real'); 4) Determine covariances among nutrients in common feeds; 5) Determine how variation in the nutrient composition of diets affect lactating dairy cows; and 6) Attempt to put a dollar value on variation. This project is ongoing (as of 2012), and it is beyond the scope of this paper to discuss all those objectives. This paper will concentrate on the degree of variation observed in nutrient composition of common feeds on dairy farms, some factors influencing that variation, and some implications of that variation on ration formulation.

Importance of Knowing Nutrient Variation

The amount of variation in the nutrient composition of a feed can affect diet formulation strategies, the economic value of the feed, the sampling and analysis schedule for the feed, and possibly the productivity and health of cows. An important component of a good ration formulation strategy is risk management. Diets are formulated, in part, to minimize the risk of a nutrient deficiency

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that would reduce production or impair cow health. The safety factor included in ration specifications are dependent on factors such as variability in cow factors (stage of lactation, milk yield, parity, etc.) within a pen, overall quality of nutritional management on a given farm (monitoring feed bunks, consistency of the total mixed ration **(TMR)**, etc.) and the variability in the nutrient composition of the ingredients in the diet. A TMR based on ingredients that are highly variable in protein concentrations will likely be formulated to a greater protein concentration than a diet based on very consistent ingredients. This over-formulation reduces the risk that the diet will be deficient in protein because of changes in the composition of the ingredients. The need for greater safety factors for variable feeds should affect the economic value of the ingredients. For example, a diet might be formulated to contain 16% CP when based on consistent ingredients, but when based on a highly variable ingredient, the diet might be formulated to contain 17% CP. The price of the highly variable ingredient must be discounted enough to cover the cost of feeding the higher protein diet. This also has an environmental cost (i.e., greater N excretion) and in many locations that translates directly into an direct economic cost. The goal of an optimal sampling (and analysis) schedule is to minimize cost. Sampling too frequently increases feed analysis cost, but sampling too infrequently may result in lost production or health problems because a change in diet composition was not identified in a timely manner. Feeds that are extremely consistent will have a very different optimal sampling schedule than that of highly variable feed. At this time, very little is known about how variation in nutrient composition of the ration affects productivity of dairy cows, but if ration variation affects the cow, then the cost of lost milk (or health problems) will have to be factored into the valuation of the ingredients.

Variation in Nutrient Composition of Feeds

Two excellent sources for nutrient composition data (including variation) of common feeds are the websites maintained by: DairyOne Cooperative (Ithaca, NY): www.dairyone.com/Forage/services/default.asp and Dairyland Laboratories Inc. (Arcadia WI): www.dairylandlabs.com/. (Note: Other qualified labs are available for feed analysis)

For many feeds, these data bases include thousands of samples from a wide geographic area, multiple years, multiple hybrids and varieties, diverse growing conditions, different manufacturing systems (e.g., distilleries or flour mills), etc. so that the data from those sources represent a national population. In other words, if you take a random sample of corn silage or distillers grain from the U.S., it would likely fit the population of samples in those 2 data bases. Although national data are valuable, they most likely do not accurately reflect variation in nutrient composition in feedstuffs within a farm. As a population becomes more specific (e.g., corn silage from across the US vs. corn silage grown on Farm X in 2012), we expect the standard deviation to become smaller because many fewer sources of variation occur on Farm X than what occurs across the U.S. Knowing variation in feed composition at the farm level, rather than at a national or global level, will allow us to fine tune ration safety factors, compare economic value of feeds more accurately, and set up optimal sampling schedules for specific farms.

Methodology

To determine variability in feed composition at the farm level, 50 well-managed dairy farms from across the U.S. (20 within Ohio, 30 outside of Ohio) were enrolled in this project. The nutritionists for the farms were given a detailed sampling protocol so that sampling procedures would be consistent across farms and then all major ingredients added at the farm to the TMR mixer for the 'high group' were sampled once monthly. Nutritionists were free to add new ingredients or stop feeding ingredients at their discretion. All samples from all farms were sent to a common lab (Cumberland Valley Analytical Services, Hagerstown, MD) and analyzed via wet chemistry for DM, CP, NDF, ash, and major minerals (ash and minerals will not be discussed in this paper). Statistics on nutrient composition were then calculated within each farm and feed. If a farm identified different populations of a feed, statistics were calculated for each designated population. For example, if a farm sent in samples identified as "bunker corn silage" and "bag corn silage", those 2 feeds were kept separate. If samples were designated simply as corn silage, all samples were considered to be from the same population. The final data set contained 4700 samples from 49 farms (one farm dropped out of the project) from 10 states (CA, IA, MI, NM, NY, OH, SD, UT, TX, and WI). Data from 49 general ingredients (i.e., all corn silages were considered one ingredient even though farms may have used 2 different corn silages), plus samples of commercial mixes, preblends, and TMR, were obtained. For this analysis, ingredients had to be sampled at least 4 times on a specific farm during the 12 month period and had to be fed by at least 5 farms. Many feeds met that criteria, but for this paper, discussion will be limited to corn silage, legume hay, legume silage, small grain silage, straw, dry shelled corn, high moisture corn, dried distillers grains, soybean meal, and wet brewers grains.

Short term (day-to-day rather than over a year) variation in haycrop silage and corn silage was evaluated by sampling those silages on 14 consecutive days on 8 farms near Wooster, OH. On 4 of those farms, independent duplicate samples (multiple handfuls were taken, mixed, and a subsample was placed in a bag and then that process was repeated) were taken each day. Corn silage was assayed for DM, NDF, and starch, and haycrop silage was assayed for DM, NDF, and CP. All assays were conducted in duplicate at the OARDC Dairy Nutrition Lab using standard wet chemistry methods.

Day-to-Day Variation in Nutrient Composition of Silages

Within a farm and over a relatively short period, day-to-day variation in nutrient composition of silages on many farms was substantial (Figure 1 and Table 1). For corn silage, the day-to-day variation in starch was greater than NDF, which was greater than DM [coefficients of variation **(CV)** were 9.5, 6.2, and 5.3, respectively]. The day to day variation in those nutrients did not follow any discernable pattern (Figure 1). For the 8 farms, the **average** range in starch concentration in corn silage was 12.2 percentage units over a 14 day period. The most consistent corn silage (within a farm) had a range in starch concentration of 6.3 percentage units, and the most variable had a range of 27.7 units (Table 1). If that variation is real (i.e., not caused by sampling or laboratory error), a deviation of about 14 units from the mean (i.e., half the range) would alter the starch concentration of the diet by about 3.5 percentage units if silage comprised 25% of the TMR. That degree of change could be enough to cause rumen upset. Day-to-day variation in corn silage NDF was also substantial, but the variation was more consistent from farm-to-farm than the farm-to-farm variation in starch. The most consistent farm had a range of 7.3 percentage units in NDF; whereas, the most variable farm had a range of 11.2 percentage units in corn silage NDF. For the most variable farm, a deviation of 5.6 units from the mean would change TMR NDF by about 1.4 percentage units (assuming corn silage had a 25% inclusion rate). Although DM was more consistent than the carbohydrates, it still ranged within a farm from 5.1 units up to 10.4 units. Because diets are formulated on a DM basis but delivered on an as-fed basis, a deviation of 5 percentage units in DM could substantially alter diet composition.

For hay crop silage, DM was most variable, followed by CP, and then NDF (CV = 8.5, 5.8, and 5.0, respectively). The range in variation between farms was large (Table 1). The range in DM concentrations within a farm was more than 5 times greater for the least consistent hay crop silage compared with the most consistent. The range in NDF and CP varied about 4-fold between the most and least consistent haycrop silages. Contrary to conventional wisdom, within a farm over a short period of time, haycrop silage was a more consistent source of NDF than was corn silage (5.0 vs. 6.2 CV for haycrop and corn silages, respectively).

Even though day-to-day variation in corn and haycrop silages was substantial, it was much less than what was observed in the national population. The average standard deviation within a farm was 2 to 3 times less than the SD for the national population (Table 1). When developing optimal sampling schedules, if actual variance on a given farm is not known, the average within farm SD shown in Table 1 would be more accurate than using the national SD.

An obvious question is: Why is corn and haycrop silages so variable over a short period of time? One possible reason is laboratory error; however, all assays were conducted in duplicate, and averaging the duplicate values had essentially no effect on SD, CV, or ranges when compared to using a single laboratory value for each day (data not shown). Another potential source of variation is sampling error. Sampling error can be defined as variation among samples from a defined population (assuming no laboratory error). For example, if you had a pile of 2000 lb of corn silage that was going to be fed to a single pen of cows today and you took 10 samples from the pile, the variation among those samples is sampling error (again assuming no analytical error). To evaluate sampling error, duplicate samples were taken each day on 4 farms. Averaging the results from the duplicate samples reduced variation by 13 to 25%, depending on the nutrient and type of silage (Figure 2). Sampling error is clearly an important source of variation, and it is probably greater than our estimates because with the sampling protocol we followed, 2 duplicate samples may not have been adequate to represent all the sampling error. Indeed a substantial amount of the day-to-day variation we observed over the 14 day period is most likely sampling error. Even though the cow does not experience sampling error, it can have a significant impact on diet formulation and the cows. High sampling error means that you should not have great confidence in the results from a single sample. Rather, multiple samples should be taken over a short period of times (days) and the average of those samples should be used for diet formulation. We used Monte Carlo techniques to randomly select samples from the 14 day-to-day study and determined that the mean of 3 samples consistently matched the overall mean (over 14 days) for NDF within each farm. A single randomly selected sample was within +/- 5% of the mean only 50% of the time.

The effect of an ingredient on the variation observed in the TMR is dependent on variation in the ingredient and on the inclusion rate of the ingredient. The effect an ingredient has on the variation of the total diet changes with the square of the inclusion rate. This means that when the inclusion rate of an ingredient is doubled, its effect on total diet variance does not increase by a factor of 2, but by a factor of 4 (i.e., 2 squared). Relying on multiple ingredients, each with a limited inclusion rate, can greatly reduce variation in the TMR. This is illustrated in Figure 3. The NDF concentrations of corn silage and hay crop silage from 2 farms are highly variable day-to-day; however, if the TMR contained 25% corn silage and 25% haycrop silage, the concentration of forage NDF in the diets is less variable. In Farm A (Figure 3), the CV for corn silage and haycrop silage are 5.3 and 4.3 respectively, but the CV for the mix is only 3.7. For Farm B, the CV for corn silage is 7.3 and 2.9 for haycrop, and for the mix, it is 4.3. For both farms, the CV of the mix is much less than the average of the CV for the 2 forages.

Month-to-month variation in forages

Measures of the month to month variation in nutrient composition of forages within farms are shown in Tables 2 and 3, and variation in concentrate feeds are shown in Tables 4 and 5. For comparison purposes, means and SD of the same feeds but for the national population are shown in Table 6. General observations include:

1. As expected, DM concentrations of silages were much more variable than DM concentrations of dry forages, and corn silage DM was less variable than the haycrop silage DM (Figure 4).

2. Relative variation in CP concentration were similar among the forages except for straw but the high CV for straw is misleading because straw has such a low concentration of CP.

3. The variation in NDF concentration varied among forages (legume hay was most variable, then legume silage, then small grain and corn silages, and straw was most consistent).

4. Unexpectedly, the relative variation in corn silage NDF over 12 months was essentially the same as observed over a period of 14 days (Tables 1 and 2). However, as would be expected, the average variation in NDF of haycrop silage over a 12 month period was substantially greater than what was observed over a 14 day period (CV = 8.7 vs. 5.0).

5. The average SD (within farm) for DM, CP, and NDF were usually one-third to one-half as great as the SD for the national population, except for legume hay. The SD for legume hay in the limited population (Table 3) may have been similar to the national population (Table 6) because farms often purchase hay from national markets.

More important than average within farm variation in forage composition is the range in within farm variation that was observed (Table 3). Some of the farm-to-farm differences in variability could be caused by sampling variation (different people sampled at different farms, storage structures differed, etc.), but some is likely real variation. For the forages on the most consistent farms, the range in CP and NDF concentrations were so small as to have little biological (and economic) importance. On the other hand, for the most variable farms, the range in NDF was 16 to 22 percentage units, depending on the forage (8 to 11 percentage unit deviation from the mean). At a 25% inclusion rate, this amount of variation could change forage NDF concentrations of the TMR by 2 to 3 percentage units. The range in CP concentrations for the least consistent farms is great enough to also cause substantial change in CP concentration of the TMR. For the most consistent farms, repeated sampling of the forages would be unnecessary; however, for the more variable farms, frequent sampling would be needed to quickly identify when forage composition changed.

Month-to-month variation in concentrates

As expected, the average variation in DM, CP, and NDF for the concentrates was less than for the forages (Tables 2 and 4). However, variation in NDF in many of the concentrates was substantial. In most situations, the **average** within farm variation in CP or NDF concentrations would have minor effects on TMR nutrient composition. The average deviation (range divided by 2) in CP concentration for most of the concentrates would change the CP concentration of the TMR by about 0.3 percentage units with an inclusion rate of 20% (a change of 0.6 units is possible with wet brewers grains). Assuming a 20% inclusion rate and average within farm variation for concentrate NDF, diet NDF could change by 0.3 to 0.8 percentage units (a change that likely would have little effect on the cow). The average within farm SD for the concentrates was much smaller than the SD for the national population (Tables 4 and 6), even though many of those concentrates are marketed nationally. For the national population, dry corn was more variable in CP and NDF than high moisture corn, but the opposite was observed for average within farm variation. This discrepancy may be caused by sample mis-identification in the national database (e.g., ear corn identified as shell corn). In the national data base, dried distillers and wet brewers grains had similar variation in CP concentration, but the distillers grains were much more variable in NDF concentration (CV = 16.1 vs 9.1). For the average within farm variation, distillers grains were less variable in CP than were wet brewers, and the 2 feeds had similar variability in NDF.

The range in variation among farms for the concentrates (Table 5) is more important than the average variation (Table 4). For example, the DM concentration for high moisture corn from one farm varied by 19 percentage units over the year, which is enough to substantially affect the amount of corn DM fed in a diet. The largest month to month range in DM concentration of wet brewers could also affect the TMR. For most of the concentrates (the exception is wet brewers), even for the most inconsistent farm, the variation in CP probably would not cause major issues. The most inconsistent wet brewers with respect to CP could cause important changes in CP concentrations of the TMR. On farms that experienced the greatest range in NDF concentrations for high moisture corn, distillers, and wet brewers grains, the NDF concentration of the TMR could be altered enough to affect cows. The NDF concentration of soybean meal could vary tremendously; however, inclusion rate for soybean meal is usually <10%, and some of that variation is likely a result of not identifying low and high protein soybean meal as separate feeds. Assuming that concentrate feeds within a farm do not vary enough to justify sampling and nutrient analysis is clearly wrong, at least for NDF. The NDF concentration of high moisture corn, brewers grains, and distillers grains should be monitored. An often stated complaint about distillers grains is that it is too variable. Based on data in Table 4 and 5, distillers and brewers grains have similar variation, and for NDF, distillers grains were actually more consistent than high moisture corn.

Implications

1. The amount of within farm variation for specific feeds differs widely among farms. This means sampling schedules should differ widely among farms (increased sampling for farms with greater variability).

2. Day-to-day variability in corn silage and haycrop silage is very large and often as great as month-to-month variation. **Single samples should not be relied upon to provide an accurate description of the feed, and substantial changes in diet formulation should not be done based on results from a single sample.** Results from 2 or 3 samples taken within a short period of time (1 or 2 weeks) should be averaged and the average used in diet formulation. Duplicate samples taken on a single day reduced day-to-day variation but probably not enough to justify the added costs, at least on smaller farms.

3. Multiple sources of nutrients, even highly variable sources, greatly reduce the variation in the nutrient composition of the TMR.

4. For many concentrates, the CP and NDF concentrations (and DM for wet feeds) vary substantially. The variation in NDF was large enough that effects on cows might be observed if the changes in composition were not used in diet formulation.

5. A month-to-month (day-to-day) change in nutrient composition of a feed could substantially alter its inclusion rates when linear programming is used for diet formulation. If the change in nutrient composition was not 'real' (e.g., sampling

variation), multiple sampling of ingredients could actually increase variation in TMR. Averaging sample results should reduce this effect.

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Table 1. Day-to-day variation in nutrient composition of corn silage and haycrop silage on 8 dairy farms in northeastern Ohio.[1]

	Corn Silage			Hay Crop Silage		
	DM, %	NDF, % of DM	Starch, % of DM	DM, %	NDF, % of DM	CP, % of DM
Averages[2]						
Mean	38.8	40.4	31.7	43.6	47.6	17.3
SD	2.07	2.52	3.02	3.70	2.38	1.01
CV	5.3	6.2	9.5	8.5	5.0	5.8
Range, % units	7.3	8.8	12.2	11.8	8.5	3.4
Ranges[3]						
Mean	31.5 - 45.7	35.4 - 45.0	27.0 - 39.2	32.5 - 55.7	36.1 - 58.2	15.1 - 21.9
SD	1.50 - 3.04	2.16 - 3.27	2.05 - 5.26	1.00 - 6.66	0.92 - 3.64	0.37 - 1.61
Range	5.1 - 10.4	7.3 - 11.2	6.3 - 27.7	3.4 - 19.1	3.2 - 13.6	1.2 - 4.9
National Population statistics[4]						
Mean	33.4	41.7	34.0	40.1	47.0	20.5
SD	6.1	5.4	7.3	10.3	5.7	3.0
CV	18.3	13.0	21.5	25.7	12.1	14.6

[1]Samples of corn silage and haycrop silage were taken for 14 consecutive days during a time when the silages did not knowingly change (i.e., same storage structure, same growing season, same cutting, etc.).
[2]The mean, standard deviation (SD), coefficient of variation [CV; (mean/SD) x 100] and range (maximum daily value - minimum daily value) were calculated for each farm and then averaged for the 8 farms.
[3]These ranges were calculated between farms (e.g., on the most consistent farm, corn silage DM ranged by 5.1 units, but on the most inconsistent farm, it ranged by 10.4 units).
[4]Data are from DairyOne Forage (Ithaca, NY) Summary (mixed mostly legume silage was used for haycrop silage) on samples analyzed from May, 2010 to May, 2011.

Table 2. Variation in nutrient composition of forages within farms over a 12 month period.[1]

		DM, %	CP, % of DM	NDF, % of DM
Corn silage (data from 48 farms)				
	Mean	34.1	7.9	40.8
	SD[2]	2.67	0.55	2.60
	CV[2]	7.8	7.0	6.4
	Range	9.1	2.0	8.8
Legume hay (data from 21 farms)				
	Mean	87.8	21.2	37.5
	SD	2.46	2.01	4.20
	CV	2.8	9.4	11.2
	Range	8.2	6.3	13.2
Legume silage (data from 38 farms)				
	Mean	42.8	21.5	39.9
	SD	6.29	1.64	3.47
	CV	14.7	7.6	8.7
	Range	20.7	5.2	10.9
Small grain silage (data from 9 farms)				
	Mean	37.3	13.0	53.6
	SD	3.27	1.46	3.29
	CV	8.8	11.2	6.1
	Range	10.6	4.6	9.5
Straw (data from 15 farms)				
	Mean	87.8	4.7	79.8
	SD	3.78	1.16	2.41
	CV	4.3	24.7	3.0
	Range	11.7	3.4	7.3

[1]Samples were taken once monthly if the forage was fed on the farm. Samples are not necessarily from the same population (i.e., corn silage could come from different structures, fields, etc; hay crops could be different cuttings, fields, etc.). The statistics are calculated within each farm and then averaged across farms.
[2]SD = Standard deviation and CV = coefficient of variation.

Table 3. Within farm ranges (over a maximum 12 month period) in variation in nutrient composition of forages.[1]

		DM, %	CP, % of DM	NDF, % of DM
Corn silage (data from 48 farms)				
	Mean	29.9 - 43.1	6.8 - 11.8	35.1 - 51.2
	SD[2]	0.80 - 5.00	0.24 - 1.27	1.16 - 6.52
	Range	2.5 - 17.9	0.8 - 4.7	4.1 - 22.1
Legume hay (data from 21 farms)				
	Mean	72.3 - 88.5	18.3 - 24.6	30.9 - 43.9
	SD	1.17 - 9.79	1.18 - 3.62	0.68 - 7.32
	Range	2.1 - 20.7	3.7 - 11.1	1.6 - 16.6
Legume silage (data from from 38 farms)				
	Mean	27.2 - 49.9	17.8 - 23.8	32.1 - 47.3
	SD	2.93 - 11.1	0.33 - 2.64	1.21 - 6.01
	Range	8.6 - 41.3	0.9 - 9.1	2.6 - 19.0
Small grain silage (data from 9 farms)				
	Mean	31.4 - 61.7	10.3 - 17.1	42.2 - 64.0
	SD	1.67 - 4.62	0.59 - 3.76	1.36 - 6.88
	Range	4.4 - 17.1	1.6 - 13.6	4.0 - 17.2
Straw (data from 15 farms)				
	Mean	82.3 - 90.8	3.7 - 5.8	72.4 - 82.6
	SD	0.76 - 13.40	0.27 - 2.73	1.21 - 4.59
	Range	1.4 - 42.5	0.8 - 8.9	2.8 - 15.5

[1]Samples were taken once monthly if the forage was fed (not all forages were fed for 12 months on all farms). Samples are not necessarily from the same population (i.e., corn silage could come from different structures, fields, etc; haycrops could be different cuttings, fields, etc.). The statistics are calculated within each farm and then the minimum and maximum among farms were determined.
[2]SD = Standard deviation.

Table 4. Variation in composition of concentrates within farms over a 12 month period.[1]

	DM, %	CP, % of DM	NDF, % of DM
Corn grain (data from 27 farms)			
Mean	85.3	8.4	11.3
SD[2]	1.67	0.43	1.30
CV[2]	2.0	5.1	11.5
Range	4.6	1.2	3.7
High moisture corn grain (data from 23 farms)			
Mean	68.8	8.1	11.6
SD	3.04	0.58	1.87
CV	4.4	7.2	16.1
Range	9.5	1.8	5.9
Dried distillers grains (data from 11 farms)			
Mean	89.9	30.4	32.6
SD	1.31	1.02	2.25
CV	1.5	3.4	6.9
Range	3.6	2.9	6.4
Soybean meal (data from 18 farms)			
Mean	88.3	52.4	8.7
SD	0.91	1.05	0.95
CV	1.0	2.0	10.9
Range	2.5	2.3	3.1
Wet brewers grains (data from 11 farms)			
Mean	22.9	31.3	49.1
SD	1.70	2.03	2.60
CV	7.4	6.5	5.3
Range	5.5	6.3	8.1

[1]Samples were taken monthly if the concentrate was fed (not all feeds were fed for 12 months on all farms). Samples are not necessarily from the same population (i.e., different lots, multiple sources, etc.). The statistics are calculated within each farm and then averaged across farms.
[2]SD = Standard deviation and CV = coefficient of variation.

Table 5. Within farm ranges (over a maximum 12 month period) in variation in nutrient composition of concentrates.[1]

		DM, %	CP, % of DM	NDF, % of DM
Corn grain (data from 27 farms)				
	Mean	83.0 - 86.5	7.8 - 9.2	9.9 - 13.3
	SD[2]	0.39 - 4.50	0.18 - 1.14	0.40 - 2.70
	Range	1.0 - 10.0	0.5 - 2.7	1.2 - 7.7
High moisture corn grain (data from 23 farms)				
	Mean	57.3 - 77.6	6.9 - 9.1	7.9 - 23.6
	SD	0.69 - 5.76	0.24 - 0.89	0.64 - 5.85
	Range	1.5 - 19.4	0.8 - 3.2	1.9 - 18.9
Dried distillers grains (data from 12 farms)				
	Mean	86.9 - 91.8	28.1 - 39.6	31.2 - 34.5
	SD	0.58 - 2.22	0.64 - 1.97	1.12 - 5.05
	Range	1.7 - 5.4	1.5 - 6.2	3.1 - 11.9
Soybean meal (data from 18 farms)				
	Mean	87.2 - 91.2	49.6 - 53.6	8.0 - 11.0
	SD	0.29 - 3.25	0.29 - 3.69	0.22 - 3.16
	Range	0.7 - 8.6	0.6 - 4.4	0.5 - 14.9
Wet brewers grains (data from 11 farms)				
	Mean	21.0 - 24.8	25.0 - 34.3	45.8 - 54.4
	SD	1.15 - 2.58	1.47 - 3.15	1.41 - 3.66
	Range	3.7 - 9.2	4.7 - 10.0	3.0 - 12.0

[1]Samples were taken monthly if the concentrate was fed (not all feeds were fed for 12 months on all farms). Samples are not necessarily from the same population (i.e., different lots, multiple sources, etc.). The statistics are calculated within each farm and then the minimum and maximum among farms were determined.
[2]SD = Standard deviation.

Table 6. National population statistics for feedstuffs evaluated in the variation project.[1]

	DM, %		CP, % of DM		NDF, % of DM	
	Mean	SD[2]	Mean	SD	Mean	SD
Corn silage	33.4	6.16	8.4	1.02	41.7	5.40
Legume hay	91.0	1.13	21.3	2.70	38.8	5.23
Legume silage	41.3	11.00	22.1	2.92	43.7	5.55
Small grain silage	31.8	11.52	13.8	3.68	56.7	7.83
Straw	93.4	1.50	5.4	2.31	73.1	7.75
Corn grain	86.6	2.96	8.3	1.36	10.2	3.14
High moisture corn	71.2	6.14	8.6	0.81	10.0	2.53
Dried distillers grains	88.0	1.79	32.0	4.88	34.9	5.78
Soybean meal	90.9	2.47	51.4	4.79	13.4	6.74
Wet brewers grains	24.5	6.34	29.0	4.43	50.6	4.61

[1]Data are from DairyOne (Ithaca, NY) for samples analyzed from May, 2010 through May, 2011.
[2]SD = Standard deviation.

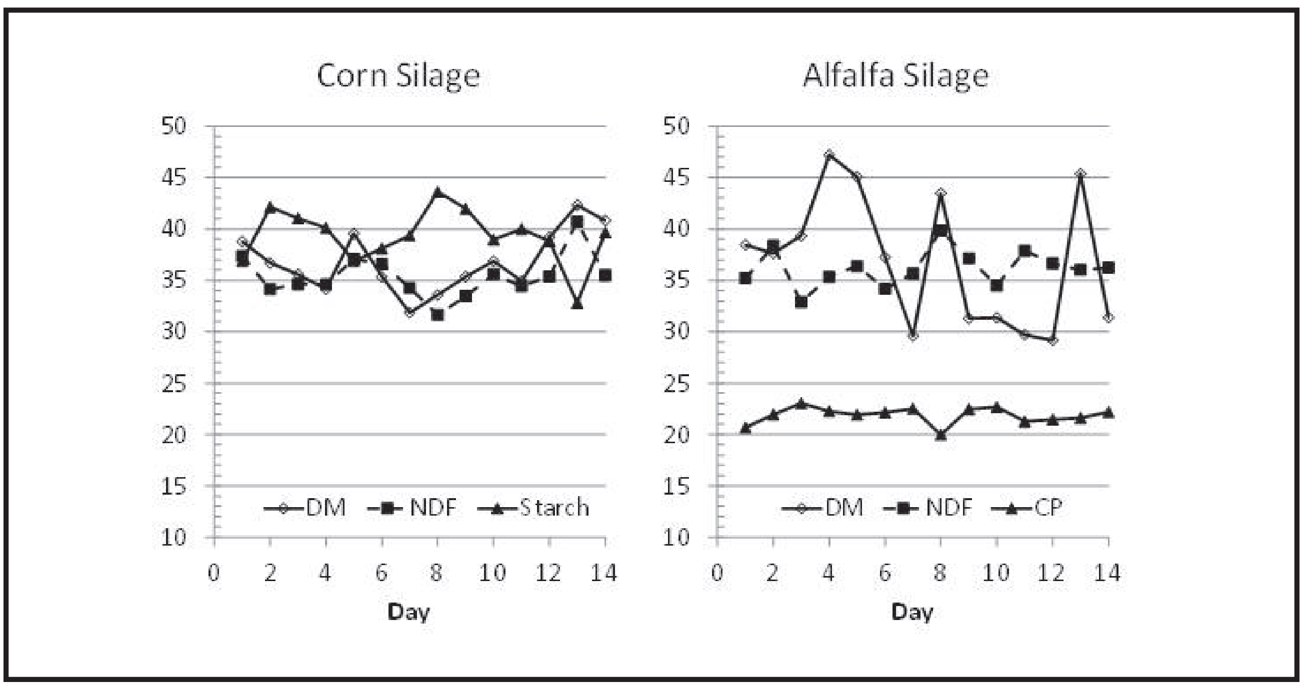

Figure 1. Day-to-day changes in DM (%) and NDF, CP, and starch (% of DM) of corn silage and haycrop silage on two farms. The farms were chosen because the day-to-day range in nutrient composition was approximately the average for the data set (see Table 1).

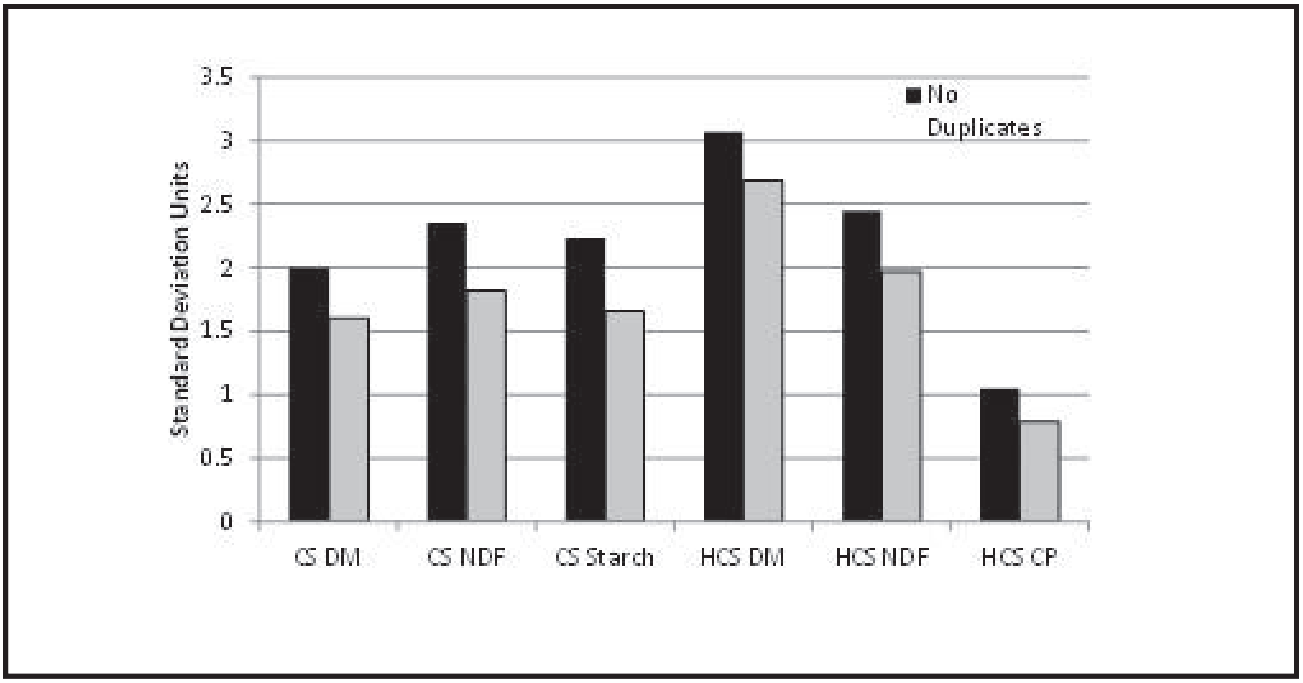

Figure 2. The effect of taking independent duplicate samples each day on variation in nutrient composition of corn silage (CS) and haycrop silage (HCS) on standard deviation within a farm over 14 days. Each bar is the average of the standard deviations calculated for each farm (4 farms).

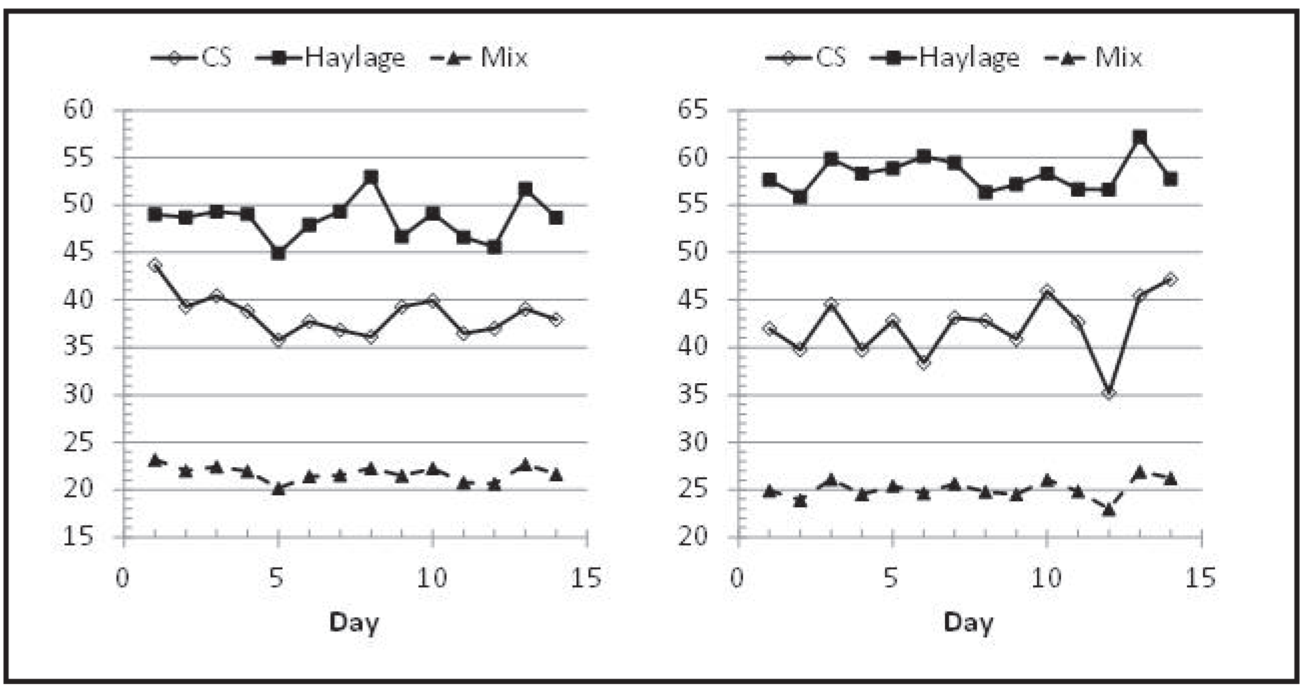

Figure 3. The effect of blending forages on reducing variation in the TMR. Forages were sampled daily and assayed for NDF. The line designated as Mix is the concentration of forage NDF in the TMR assuming corn silage (CS) and haycrop silage each comprised 25% of the TMR and no other forages were fed (data are expressed as of DM of silage or total TMR).

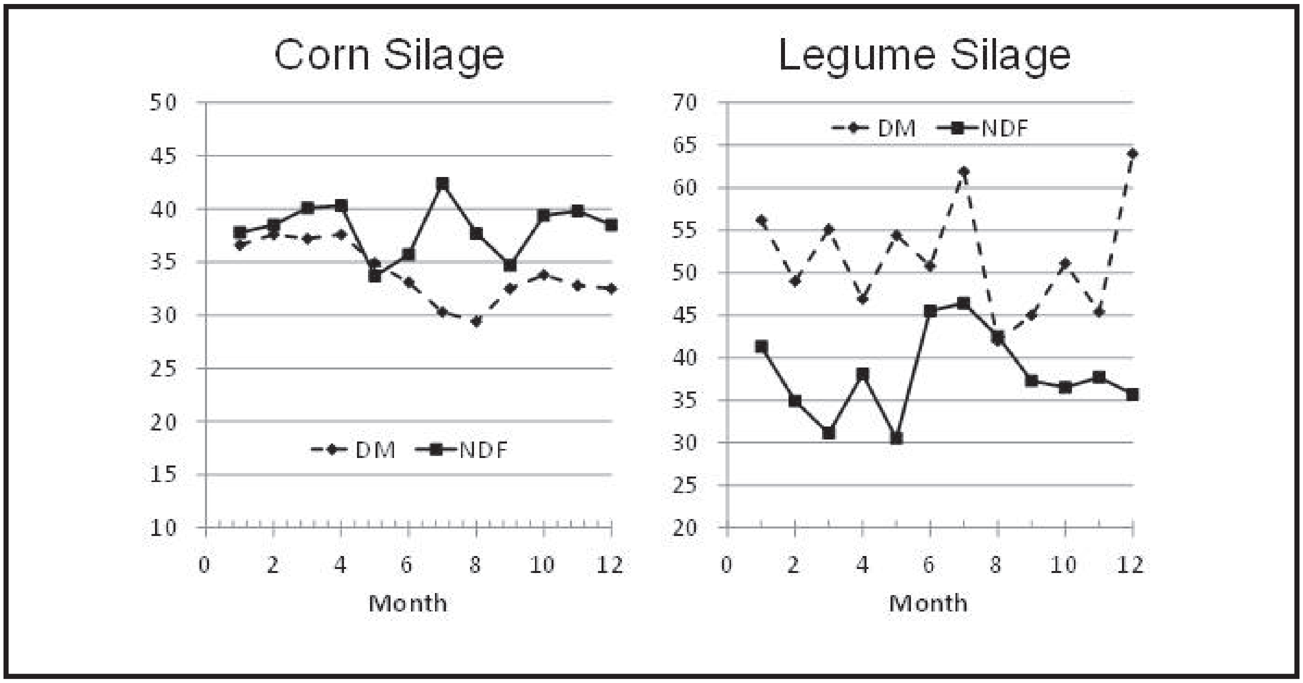

Figure 4. Month-to-month changes in concentration of DM (%) and NDF (% of DM) in corn silage and legume silage. The farms were chosen because the across months range is approximately equal to the average for the survey (Table 2).