Using Feed Analysis to Troubleshoot Nutritional Problems in Dairy Herds[1]

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Commercial feed testing labs can conduct a host of different analytical procedures to provide data for use in ration formulation and feed evaluation. Some of the data are needed only for routine diet formulation, other data are helpful in troubleshooting and feed evaluation, and some data serve both functions. Accurate feed analysis data is essential for formulating well-balanced diets and feeds should be sampled and analyzed for standard nutrients on a regular schedule to ensure the diet meets the cow's nutritional requirements. In some situations, diets that appear to be well-balanced do not result in the expected production or cows experience nutritionally-related health problems. Probable reasons for unexpected results include feed mixing errors, inaccurate feed analysis data caused by poor sampling (very common) or analytical errors, inaccurate estimates of bioavailability of nutrients, and uncertainty regarding nutrient requirements. Another very likely reason is that some measurable characteristic or component in the diet limits performance, usually by reducing dry matter intake. The purpose of this paper it do discuss how feed analysis reports can be used to solve nutritional problems on a dairy farm. An underlying assumption of this discussion is that the diet appears to be well-balanced for standard nutrients.

Use of feed analysis to determine mixing problems

One of the first steps in troubleshooting a potential nutritional problem is to make sure cows are being fed the diet that was formulated. When done correctly, sampling and analyzing the TMR when it is delivered to the cows and comparing that data to the diet formulation sheet can help determine whether a feed mixing problem exists. Variability in nutrient composition of a TMR is generally higher than variability within a feedstuff because the composition of the TMR reflects variation in feedstuff composition, variation in batch make-up, variation in mixing, and increased sampling error. Because of increased variability, the expectation that an analysis of a TMR should precisely reflect the formulated diet is not realistic. To determine whether mixing errors exist, a good sample of the TMR should be collected immediately after the ration is delivered to the pen. The entire length of the feed bunk should be subsampled randomly (e.g., take a sample every 5 paces), the subsamples should be mixed throughly and sent to a lab. Nutrients that have different concentrations among

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ingredients and can be analyzed precisely (analytical error has to be less than expected normal variation) should be measured and compared to formulation values. Nutrients that are provided primarily by ingredients with very small inclusion rates (e.g., copper) should not be used. Conclusions regarding potential mixing problems should be based on more than one nutrient and the pattern of inconsistencies should be rational relative to the composition of individual diet ingredients (Table 1). Nutrients that should be examined include dry matter (DM), neutral detergent fiber (NDF), acid detergent fiber (ADF), crude protein (CP), and calcium.

If measured TMR composition differs significantly from formulated values, feeding management should be examined. The three main reasons why the TMR presented to a cow may differ from the diet that was formulated are: inaccurate scales on the mixer wagon, mixing errors by the feeder, and changes in the dry matter (DM) content of feeds. Good feeding practices should include routine checking of mixer scales, properly training the feeder, and frequent, routine measurement of the DM content of wet feeds. The DM content of silages, especially haycrop silages can be extremely variable. This variation can be managed if silages are sampled and analyzed for DM whenever necessary. An abrupt increase in feed refusal suggests that silages became drier and an abrupt case of empty bunk syndrome suggests that the silages became wetter. In both cases, silages and other wet feeds should be immediately analyzed for DM and the TMR adjusted accordingly. Dairy operations should have the ability to measure DM on-farm.

Use of Feed Analysis to Evaluate Diets

To evaluate and troubleshoot the nutritional program of a dairy farm, the nutrient profile of individual dietary ingredients (i.e., forages, grains, byproducts, concentrate mixes) must be examined. Purchased concentrate mixes and many concentrate commodities must meet certain quality control specifications and the delivered product usually meets or exceeds the nutrient guarantees. Analyzing these feeds is usually not required. All forages, wet byproducts, byproducts from a single manufacturing site that maintains limited inventories, and homegrown grains should be sampled and analyzed. The frequency of sampling and analysis depends on expected variation in composition. The relative variability of feeds within a farm is generally: haycrop forage > corn silage = wet byproducts > other byproducts > grain. Nutrient composition data for many feeds is only needed for ration formulation but for some feeds, especially forages, analytical data is essential for nutritional troubleshooting.

Dry matter (DM)

The DM content of a TMR is not an extremely important number because when DM content of a diet is changed by adding water, no effects on intake and production have been observed over a wide range in DM contents (35 to 65%). The DM content of individual ingredients, however, can be quite important. The DM content of feeds is needed to adjust as-fed amounts so that nutrient composition of the diet is constant. In addition, potential nutritional problems can be identified by evaluating the DM content of hays and silages.

! Corn silage

Acceptable range: 30 to 40% DM (silage stored in bunkers should be in the low end of the range, silage stored in uprights and bags should be in the high end of the range).

Wet silage. An undesirable fermentation often occurs when corn silage it too wet. High concentrations of acetic acid and perhaps butyric acid and low pH is often found in wet corn silage (Figure 1). All these can cause reduced DM intake (DMI) when fed to a cow. When corn silage DM is low, and DMI is less than expected, a fermentation analysis (see Fermentation Analysis) is recommended. Dietary modifications that might be useful can be made after a fermentation analysis (see below).

Dry silage. Corn silage with high DM often undergoes a limited fermentation and is usually more mature than corn silage with normal DM content. The limited fermentation may cause reduced concentrations of acetic and lactic acid and higher than normal pH values in the silage. Silage that has undergone a limited fermentation tends to heat in the feed bunk and become moldy during feedout. Both of these problems can reduce DMI. Dry corn silage can also heat during storage, this will reduce protein and energy digestibility. A feed analysis that includes unavailable protein (ADF-bound protein) is necessary to adjust nutrient availability for heat-damage. High DM silages (even without heat-damage) are less digestible than normal corn silage because of lower NDF and starch digestibility. No current lab test can accurately estimate starch digestibility but experimental data suggests that digestibility of starch in dry corn silage is up to 10% less than that for normal corn silage. Decreased starch digestibility could reduce the energy content of dry corn silage by 5%. Changes in NDF digestibility can be monitored by having the silage analyzed for lignin or by having in vitro or in situ NDF digestibility measured (In Vitro NDF Digestibility).

! Haycrop silage

Acceptable range: 32 to 50% DM (silage stored in bunkers should be in the low end of the range, silage stored in uprights and bags should be in the high end of the range).

Wet silage. The problems discussed above for wet corn silage are the same as found with wet haycrop silage except that the likelihood of a poor fermentation is greater for wet haycrop silage than wet corn silage. Wet haycrop silages usually have high butyric acid, acetic acid, ammonia concentrations (Figure 2). Intake is often reduced when wet haycrop silage is fed (see discussion on Fermentation Analysis)

Dry silage. The problems associated with high DM haycrop silage are short bunk-life caused by limited fermentation (see dry corn silage discussion) and heat-damage during storage. Unlike high DM corn silage, high DM haycrop silages that have not been heat-damaged have equal digestibility to silages with acceptable DM contents. All haycrop silages with more than about 45% DM should be analyzed for unavailable protein and protein supplementation adjusted accordingly. Energy values should also be reduced when the silage is heat-damaged.

! Hay

Acceptable range: 85 to 88% DM for large rectangular and round bales and 80 to 85% for small rectangular bales. If an acid-preservative has been used acceptable DM concentrations may be as low as 80% for large bales and 75% for small bales.

Wet hay. Hay with less DM than acceptable will almost certainly heat and become moldy. Heat-damage will reduce protein and energy digestibility and mold will usually reduce DMI significantly. Wet, moldy hay is an unacceptable feed for lactating cows and is usually unacceptable for dry cows and heifers.

Excessively dry hay. The only problem usually associated with feeding very dry hay is leaf shatter and loss of nutrients during feed mixing and delivery. The leaves are shattered during mechanical handling and many of the particles can be lost. Since leaves have a higher concentration of protein and lower concentration of NDF than stems, the feed that is actually delivered to the animals may not be balanced for protein and NDF when very dry hay is fed.

Fermentation analysis

This analysis usually consists of pH, lactic, acetic, propionic, and butyric acids, and ammonia. This analysis can be useful in solving DMI and production problems associated with silage fermentation. The analysis is only useful to evaluate silages and to a much lesser extent high moisture corn. Normal values for pH and fermentation products vary depending on type of silage and DM content (Table 2).

Abnormal pH. Low pH is almost always associated with wet silages. Low pH often does not cause any problems but silage with low pH can reduce DMI. If DMI is lower than expected and silage (especially corn silage) has pH values lower than 3.5 to 3.7, buffering the silage may increase DMI. Studies at the Universities of Wisconsin and Maryland showed that increasing the pH of corn silage from about 3.6 to 4.5 - 5.5 increased DMI by dairy cows and heifers. The recommended procedure is to put the corn silage in a TMR mixer, add 2 to 4% (DM basis) sodium bicarbonate (for silage with 35% DM this is equal to 14 to 28 lbs of sodium bicarbonate per wet ton of silage), mix and then let the silage-bicarb mixture stand for 15-20 minutes. Then add the rest of the TMR ingredients and feed the cows.

Silages with high pH have not undergone adequate fermentation (usually caused by high DM content), are excessively buffered (high crude protein and/or high concentration of alkaline minerals such as calcium and magnesium) or are spoiled (moldy). The only problem associated with high pH silage that is not spoiled is short bunk life. If silage has a high pH and is not moldy, feeding more frequently will reduce spoilage in the feed bunk and may increase DMI and production. Silage with a high pH that is moldy or has undergone a clostridial fermentation can cause significant reductions in DMI and production. The only cure for this problem is too feed less of the silage.

Abnormal acetic acid concentration. Silages with low acetic acid concentrations are more prone to spoilage at the silage face and in the feed bunk, but if the silage is not spoiled, no problems are associated with feeding low acetic acid silage. Silages with high acetic acid usually were ensiled with excessive moisture (low DM). High acetic acid concentrations increase bunk life and reduce face spoilage but can reduce DMI. Generally DMI problems have only been observed when acetic acid concentrations are higher than 5%. If DMI is lower than expected, a silage with high acetic acid may be the cause. Unfortunately, little can be done to solve this problem except reduce the amount of the silage that is fed.

Abnormal lactic acid concentration. Good silages should have high concentrations of lactic acid. Lactic acid is almost never too high because as the concentration increases, pH decreases and then additional fermentation is inhibited. Low concentrations of lactic acid are not directly related to any production problems but indirectly low lactic acid silages often are high in butyric acid and ammonia (clostridial fermentation) which can cause problems (see below).

High butyric acid concentrations. A well-fermented silage should contain only trace amounts of butyric acid. When silage has more than 0.2 to 0.5% butyric acid, you know silage fermentation is a problem. High butyric concentrations usually only occur in wet silage. High butyric acid means that substantial nutrient losses have occurred during fermentation (increased NDF and decreased nonfiber carbohydrates concentrations and decreased digestibility). Furthermore, high butyric acid silages often contain compounds known to have pharmacological effects and usually depress DMI. Silages with high concentrations of butyric acid are related to increased risk of ketosis. Silages with more than about 0.75% butyric acid should not be fed to dairy cattle. Silages with 0.4 to 0.75% butyric acid should only be fed in very limited amounts.

High ammonia concentrations. High ammonia concentrations are almost always found when butyric acid concentrations are high so it is difficult to separate the effects. High ammonia concentrations caused by adding anhydrous ammonia to corn silage (7 to 9 lbs. per wet ton) are not associated with DMI or production problems. If silage ammonia is high because of poor fermentation (i.e., butyric is also high) the silage should either not be fed or fed in very limited amounts.

Neutral detergent fiber (NDF)

The concentration of NDF in the TMR and in the forages have a substantial influence on performance and cow health but simply evaluating the NDF content of the TMR is not adequate. The source of the NDF and particle size of the ingredients providing large amounts of NDF must be considered. Almost any diet with less than 25% NDF increases the risk for ruminal acidosis, but many diets require higher concentrations to prevent health problems (see NRC, 2001 for recommendations). Diets with high concentrations of NDF can reduce DMI but the source of the NDF has more effect than dietary concentration. When dietary NDF is increased by increasing the concentration of forage in the diet or by increasing the NDF content of the forage, DMI usually decreases when diet NDF is greater than 30 to 32%. When diet NDF is increased by the addition of high fiber byproducts DMI often does not decrease until NDF concentration are higher than 35 to 40%.

! Corn silage

The relationship between NDF concentration of corn silage and cow performance is not consistent. In haycrop forages, NDF concentration is correlated with maturity and negatively correlated with NDF digestibility, but these relationships are not found with corn silage. The concentration of NDF in corn silage actually has a slight negative correlation with maturity (as corn plants become more mature, NDF concentration tends to decrease because of dilution by starch in the kernel). In a Wisconsin study (Bal et al., 2000) diets with a low NDF corn silage (33% NDF) or normal NDF corn silage (39%) were fed to lactating dairy cows. Dry matter intake was about 1 lb./day higher for cows fed the normal NDF corn silage but no effect was observed for milk production or milk composition. We recently completed a study comparing normal NDF corn silage (42%) to a high NDF silage (49%). We found no differences in DMI, milk production, or digestibility. These data suggest that NDF content of corn silage within a fairly wide range (33 to 49%) appears to have little effect on cow performance.

! Haycrop forages

High NDF forages. Within a forage classification (i.e., legumes or grasses), increasing NDF content of the forage usually results in decreased DMI and decreased milk production when fed to high producing cows. For alfalfa, significant reductions in DMI can occur when the forage has more than 40 to 42% NDF. This can occur even if total diet NDF is constant (i.e., lower forage:concentrate ratio). The effect of increased concentration of NDF in alfalfa is greatest for early lactation, high producing cows. In a review of several studies with alfalfa (Weiss, 1999), DMI was reduced an average of 0.12 lbs/day and milk production was reduced an average of 0.36 lbs/day per one-unit increase in NDF concentration of alfalfa above 40% when fed to cows producing more than about 70 lbs. of milk (Figure 3). When data from cows producing less than 70 lbs of milk was used increasing NDF content of the alfalfa above 40% had no effect on DMI or milk production. If DMI is a problem, examine the NDF content of the haycrop forage. If the diet contains alfalfa with more than 40 to 42% NDF (even if total diet NDF is not excessive), forage quality may be the reason for low DMI. Reducing the amount of high NDF alfalfa may help. Less information is available for grass forages but the limited data would suggest that DMI can be severely limited when grasses with more than about 55% NDF are fed to lactating cows.

Low NDF forages. Based on NRC (2001), cows have a requirement for forage NDF and when this requirement is not met, the risk of ruminal acidosis increases. Balancing diets with forages that have extremely low NDF concentrations is difficult. Although no problems have been associated with feeding haycrop forages with low NDF when diets are balanced properly, harvesting forages that are excessively immature or purchasing hay with very low NDF concentrations are difficult to justify economically. Alfalfa with <35% NDF is usually not worth anymore, and may be worth less, than alfalfa with 35 to 40% NDF.

In vitro NDF Digestibility (IVNDFD)

In vitro NDF digestibility is a relatively new test offered by many labs. The test can be valuable in solving DMI problems, but its value in routine diet formulation is limited. Interlab, and to a lesser extent intralab, repeatability can be a problem (each lab has a unique source of rumen fluid). Forages with high IVNDFD tend to be consumed in higher amounts than forages with low IVNDFD, but because of interlab variation a typical or normal value cannot be given, but many labs will provide mean values from their lab for a given type of forage. This test is very good at comparing different lots of the same type of forage (e.g., silos) within a farm. The forage with the higher IVNDFD should be fed to early lactation, high producing cows. Oba and Allen (1999) reported that a 1-unit increase in IVNDFD was associated with an average increase of 0.3 lb/day in total DMI and an average increase of about 0.5 lbs/d of milk yield. Because precision for this assay is not high, values have to be different by several units before you would expect to see a response. If a group of cows have lower than expected DMI, this test might be able to determine whether NDF digestibility is limiting DMI. Forages with IVNDFD values lower than the lab reference value suggest that fiber digestibility could be the cause for low DMI. The only remedy is to feed less of the low digestibility forage.

Particle size

Some labs offer particle size analysis, usually using the “Penn State Separator”. This device consists of a pan, a middle sieve with 0.3 inch holes and a top sieve with 0.75 inch holes. Recommend particle size distributions for silages and TMR have been published (Heinrichs, 1996), however, several questions have been raised regarding these recommendations. In my opinion, the Penn State recommendations are really average values found in the field and not necessarily recommended values. New research found that cows fed alfalfa silage-based diets at particle sizes much smaller than recommended had normal rumen health, normal milk fat, and actually consumed more DM than cows fed silage with the recommended particle size. Research we conducted at Ohio State found that particle size of corn silage in corn silage-based diets could be much shorter than recommended without adverse effects on rumen health or production. Particle size of forages is important but because so many factors affect the 'effective fiber' requirement, simple recommendations for particle size distribution are not very meaningful. Changes in dietary NDF and nonfiber carbohydrate concentrations will greatly affect particle size 'requirements'. In my opinion, field application of particle size analysis has limited value. I do not know what particle size is required and therefore cannot evaluate the results.

One useful application of particle size analysis is evaluation of feed refusals. With a TMR system we assume that what cows are offered is what they actually consume. Comparing particle size of the TMR with particle size of the refused feed shows whether substantial feed sorting is occurring. If the refusals have a much larger particle size, it means that actual intake of forage and NDF (most large particles are forage which usually contains most of the NDF) is less than anticipated. This could result in ruminal acidosis problems. If cows exhibit signs of subclinical acidosis and the formulated diet looks ok, comparing particle size of refusals to the diet is very useful. If sorting is evident, either the diet has to be reformulated to account for sorting or feeding management needs to be changed to reduce sorting. The most rational formulation change would be to overbalance for NDF (reduce the starchy ingredients and increase high NDF byproducts). Feeding management changes that might reduce sorting include feeding smaller meals (allowing the feed bunk to be empty for short periods of time), increasing the water content of the TMR (this will only help if the forage is too dry), or increasing mixing time (do not increase it too much because the resulting diet may be too finely chopped).

References

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Table 1. Examples of interpreting measured TMR values relative to formulated values.

Observation	**Probable Explanation**
Diet: corn silage, alfalfa silage, dry concentrate with no high fiber byproducts	
Measured DM > formulated	Less silage in diet than formulated or DM content of silage(s) increased
CP > formulated	More alfalfa silage or more concentrate in diet than formulated
NDF > formulated	More silage in diet than formulated
Ca > formulated	More alfalfa silage in diet than formulated
	Conclusion: DM content of alfalfa silage increased so more alfalfa silage DM in diet than formulated
Measured DM < formulated	More silage in TMR than formulated or DM content of silage(s) decreased
CP < formulated	More corn silage in diet than formulated
NDF > formulated	More silage in diet than formulated
Ca = or < formulated	Alfalfa silage about as formulated
	Conclusion: TMR has more corn silage than formulated
Diet: corn silage, limited alfalfa hay, wet brewers grain, dry concentrate	
Measured DM = formulated	Total amount of corn silage + wet brewers about as formulated
CP > formulated	More brewers grains, less corn silage, more hay, or more concentrate than formulated
NDF = formulated	Total amount of corn silage + brewers + hay about as formulated
ADF < formulated	Less corn silage, more or less brewers, or less hay than formulated
Ca = formulated	Total amount of corn silage + brewers + hay about as formulated
	Conclusion: The amount of hay fed is probably about correct and total amount of corn silage plus brewers is about as formulated. The proportion of brewers grain is high relative to corn silage.

Table 2. Fermentation parameters for well-fermented silages (DM basis).

	Alfalfa (30-40% DM)	**Alfalfa (45-55% DM)**	**Corn silage**
pH	4.3 - 4.7	4.7 - 5.0	3.7 - 4.2
Lactic acid, %	>7	2 - 4	4 - 7
Acetic acid, %	2 - 3	1 - 2	1 - 3
Butyric acid, %	< 0.4	< 0.1	< 0.1
Ammonia-N, % of CP	< 15	<12	< 7

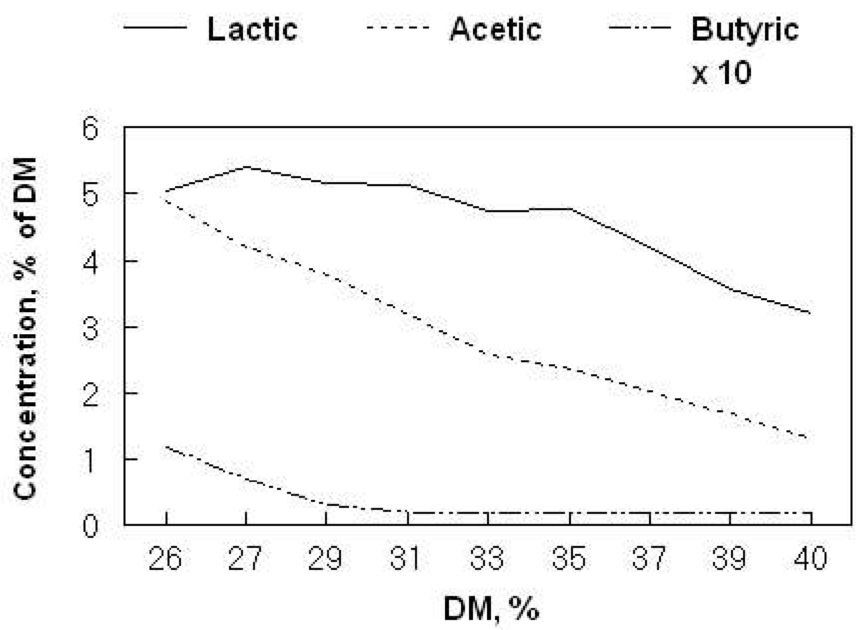

Figure 1. Relationship between DM content of corn silage when ensiled and concentrations of fermentation acids. The values for butyric acid were multiplied by 10 for illustration purposes (e.g., average concentration of butyric acid in corn silage at 26% DM is about 0.12%).

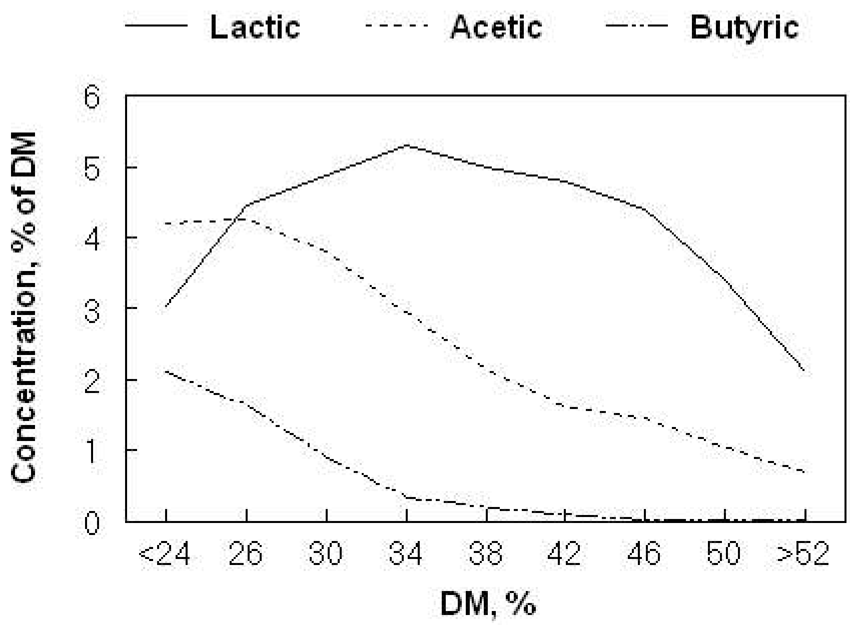

Figure 2. Relationship between DM content of alfalfa silage when ensiled and concentrations of fermentation acids.

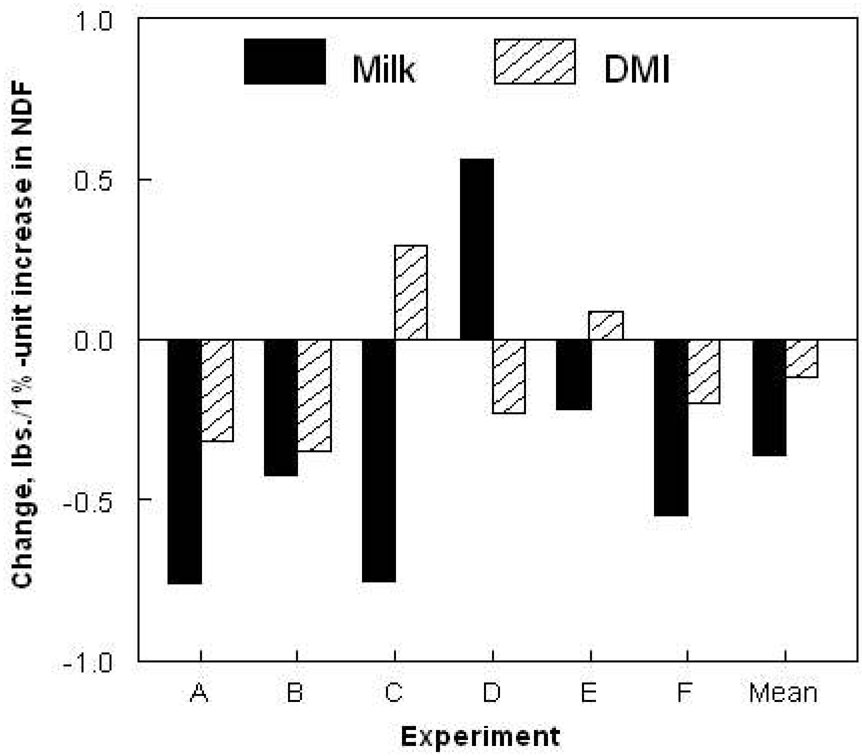

Figure 3. Effect of a 1-percentage unit change in NDF concentration of alfalfa forage on milk yield and dry matter intake of cows producing more than 70 lbs. of milk per day. Average diet contained 55% forage. Range in NDF concentration of the alfalfa was 37 to 52% of DM (Weiss, 1999).