

Effects of Variation in Nutrient Composition of Diets on Lactating Dairy Cows

William P. Weiss^{1,2,3}, Peter Yoder², Lucien McBeth²,
Dianne Shoemaker³, and Normand St-Pierre^{2,3}

*Department of Animal Sciences² and Ohio State University Extension³
The Ohio State University*

Summary

The nutrient and ingredient composition of diets vary over time. A survey found that within farm coefficients of variation (**CV**) based on monthly sampling of the TMR over a year averaged about 5% for the concentrations of major components (dry matter, fiber, and protein). Based on ingredient variation found in that survey, the day-to-day CV is likely similar to the month-to-month CV. We conducted a series of 3 experiments to examine the effect of variation in diet composition on lactating dairy cows. In one experiment, substantial variation over 4 day cycles in dietary concentration of long chain fatty acids (from corn oil) reduced intake and milk yield of dairy cows but moderate variation had no effect. In a second experiment, transient reductions in silage dry matter (**DM**) concentrations (similar to what might occur when uncovered silage was rained upon) did not negatively affect cows if adequate feed was provided to the cows each day. In the third experiment, extreme daily variation in forage quality (fiber and protein) did not affect average milk yield or average intake by cows. Cows appeared to be able to compensate for days when the diet had lower quality forage, and intake was depressed by mobilization of body energy and by consuming additional feed on days when the diet was better (i.e., lower in fiber). Overall, these data indicate that cows can handle short term (a few days) variation in many nutrients.

Introduction

If you have read articles or attended conferences about dairy cattle nutrition, you have likely heard or read something to the effect, “cows do better when fed a diet that is consistent day to day”. Although this seems to make sense, essentially no research has evaluated the effect of diet inconsistency on dairy cows. A group of Extension specialists and researchers at The Ohio State University has spent the last several years addressing the question: “does short term or transient variation in diet composition affect cows?” Diets can exhibit transient variation for a host of reasons and an almost infinite number of dietary characteristics can vary. The concentrations of a multitude of nutrients in feedstuffs that comprise the TMR can vary, dietary inclusion rates of ingredients can change, the ingredients used in the TMR can change, physical characteristics of the diet (e.g., particle size) can vary, and the list goes on. This paper will discuss recent experiments conducted at The Ohio Agricultural Research and Development Center that were designed to evaluate the effects of transient diet variation on lactating cows.

Are Diets Consistent?

Common ingredients used in dairy cow diets can show substantial day-to-day and month-to-month variation in nutrient composition based on a survey of dairy farms across the U.S. (Weiss et al., 2012). In that survey, the smallest range within a

¹Contact at: 1680 Madison Ave., Wooster OH 44676; (330) 263-3622; FAX: (330) 263-3949; Email: weiss.6@osu.edu



farm in concentrations of DM, neutral detergent fiber (**NDF**), and starch in corn silage when sampled daily for 14 days was about 4 percentage units. However the maximum range we observed within a farm (not necessarily the same farm) for DM, NDF, and starch was 12, 17, and 27 percentage units, respectively. Haycrop silage showed a similar maximum range in NDF concentrations, and the maximum range in DM concentration was 21 percentage units (remember this was over only 14 days). Over a 12 month period with monthly samples, ranges in concentrations of the nutrients were just slightly greater than what we observed over a 14 day period. Variation in several concentrate feeds can also be substantial within a farm, or between and within manufacturing facilities, such as an ethanol plant (Kertz, 1998; Belyea et al., 2010; Buckner et al., 2011; Weiss et al., 2012).

If a TMR is made correctly (no errors in amounts of feeds added) then the variation in nutrient composition of a TMR should be less than that of the ingredients because composition of the ingredients are independent of each other. For example, if the TMR contains alfalfa silage and corn silage, on a given day the alfalfa silage may have higher than expected NDF but the corn silage could be lower; therefore, the combination of the 2 feeds would be closer to expected than either individual ingredient. Limiting inclusion rates and using multiple ingredients will reduce variation in the TMR if the TMR is made correctly. However, sampling error is likely high for TMR because of the heterogeneous nature of the particles which makes estimating the ‘real’ variation in a TMR difficult and can bias direct comparison of nutrient variation of a TMR to that of ingredients. We conducted a survey of 50 farms across the U.S. in which the TMR fed to the “high group” was sampled monthly by the farm’s nutrition consultant following a specific sampling protocol. Measures of month-to-month variation in TMR composition within a farm are shown in Table 1. The average coefficients of variation (**CV**) for DM,

CP, and NDF are less (in many cases substantially less) than what we observed for individual ingredients (Weiss et al., 2012). Some farms were extremely consistent month-to-month, but the most inconsistent farms had substantial month-to-month variation in DM, CP, NDF, and ash. Variation in sodium concentration is shown because it can be a good index of sampling or mixing error. Most feedstuffs, except for a few minerals (e.g., salt, sodium bicarbonate, or monosodium phosphate), have very low concentrations of sodium. The very high average CV and very high maximum CV for sodium suggest that sampling and or mixing errors can be a major problem.

Why Do Diets Vary?

The composition of feed ingredients can vary for numerous reasons (Figure 1), including growing conditions, field differences (soil, fertility, weed pressure, etc.), hybrid or variety, planting and harvest dates, storage and feed out conditions, and manufacturing processes (e.g., brewery or distillery conditions). Those sources of variation could be considered ‘natural’, often follow a random pattern, and our ability to reduce that variation is somewhat limited. The TMR will reflect some of the variation in ingredients, but because multiple ingredients are blended together, the effect of ingredient variation is reduced in a TMR. The composition of a TMR will also vary because of mixing errors [inaccurate TMR scales, operator mistakes, or lack of standard operating procedures (**SOP**)] and not adjusting inclusion rates for changes in DM concentrations of wet feeds. This variation is also likely random, but it is controllable by proper training, written SOP, equipment maintenance, and adequate feed sampling and analysis (Figure 1). Another source of short term variation in TMR composition is what we call, “nutritionist-induced variation”. This is variation caused by excessive reformulation of diets, perhaps because of frequent changes in ingredient prices (e.g., least-cost formulation). Diets are also reformulated because ingredient composition has

changed or has appeared to change based on a sample result. If the ingredient truly changed (i.e., you have multiple samples that indicate composition has changed) and the new feed composition data reflect that change (i.e., the mean of multiple samples), then the reformulation does not increase variation in composition; actually it should reduce transient variation. However, if the new composition data are not representative of the feed (i.e., sampling error), then reformulating based on the poor information increases transient variation because the ingredient inclusion rates will change to compensate for a change in nutrient composition that did not actually occur.

The variation discussed above is variation in delivery of nutrients to the cow, not necessarily variation in consumption of nutrients by the cow. Within a day or over multiple days, cows may choose to consume a variable diet. A study with grazing dairy cows measured self-selected intake of ryegrass or clover over a day (Rutter et al., 2004). Cows were given access to adjacent monocultures of white clover or ryegrass. For one treatment, 75% of the total land was a white clover monoculture and 25% of the land was ryegrass. For the other treatment, 25% of the land had a white clover monoculture and 75% contained a ryegrass monoculture (all cows were also given approximately 4 lbs of concentrate at each milking). For 2 days, intake of the different types of grazing forage was monitored hourly. Cows exhibited very substantial hour-to-hour variation in consumption of grass or legume (Figure 2; for clarity, only data for the 25:75 clover:ryegrass treatment are shown). Whether the hour-to-hour variation in ingredient selection corresponds to high variation in nutrient delivery (e.g., NDF or CP) cannot be determined because nutrient analysis of the 2 forages was not presented. The reasons cows showed such a high degree of hour-to-hour variation in consumption of clover or grass are not known, but the authors (Rutter et al., 2004) suggested it may be behavioral or it may be an attempt by the cow to maintain

efficient rumen function (e.g., consumption of grass may provide necessary fiber). Data on hourly consumption patterns of specific ingredients or nutrients for cows fed TMR are not available; however, limited data on day-to-day diet selection are available (Armentano and Leonardi, 2003). They measured variation in intake of different particle sizes (which should also reflect variation in nutrient intake because larger pieces tend to be forage which should have a greater concentration of NDF than smaller concentrate particles). They found substantial cow-to-cow variation in the desire (or ability) to sort diets, but many cows that did sort, sorted consistently. In other words, a cow that was a good sorter against long particles, consistently sorted against long particles across diets and across days. This suggests that although a cow may not be consuming the diet that was formulated, the diet she is consuming can be relatively consistent.

Does Diet Variation Affect Cows?

Dozens of experiments have been conducted comparing diets with 15% CP to those with 17%, or diets with 2% added fat to diets with 4% added fat, etc. In our series of experiments, we were not interested in whether diets that differed in concentrations of a specific nutrient affected cows differently. We wanted to determine whether diets that were, on average, equal in a specific nutrient but differed in day-to-day variation, affected cows. In other words, rather than diet composition being the treatment, diet variability was the treatment. Very few experiments with cattle (or any other animal) have had diet variation as a treatment. The effects of oscillating protein concentrations (i.e., dietary CP concentration follows a cyclic pattern of high concentration for a day or two, followed by low concentration for a day or two with that pattern repeating) compared to constant dietary CP have been studied in growing beef cattle and sheep. Growth rates were generally not affected (oscillating treatment compared to a treatment with constant dietary protein at the same concentration as the

average of the oscillating treatment), but nitrogen retention, nitrogen retention efficiency (nitrogen retained per unit of nitrogen consumed), and efficiency of converting dietary gross energy to metabolizable energy was greater for the oscillating treatment than the control (Cole, 1999; Archibeque et al., 2007). Midlactation dairy cows that were fed a consistent diet with 15.5% CP, a treatment with moderate day-to-day variation in CP concentration (13.5 or 17.5% CP, alternating daily), or a treatment with high day-to-day variation in CP concentration (11.5 or 19.5%) had similar milk yields, similar DM intake, and similar milk composition (St-Pierre and Gerstner, 2005). The frequency or duration of the change probably has a substantial impact on cow responses to diet variation. For dietary protein, 1 day of low protein may not have been long enough for cows to respond because the contents of the rumen and intestines do not completely turnover every day. We may have to evaluate variation in a timeframe longer than a 24 hr day.

The current project involved 3 experiments with lactating dairy cows. Experiment 1 examined the effect of varying the concentration of supplemental dietary fat (high in unsaturated fatty acids) in 4 day cycles (Weiss et al., 2013). The second experiment evaluated the effect of a transient (3 day) change in silage DM concentration (McBeth et al., 2013). The third experiment compared a consistent diet to a treatment that varied daily in forage NDF concentration and to a treatment in which the forage-to-concentrate ratio varied in a cyclic pattern (Yoder, 2013; Yoder et al., 2013).

Short term variation in dietary concentrations of unsaturated fatty acids

This experiment (Weiss et al., 2013) was conducted because of the very large variation in fat concentration that can be found in some distillers grains. Distillers grains are usually made from corn, and corn oil (i.e., the fat in distillers grains) is high in

polyunsaturated fatty acids. The control diet was consistent for the 16 day experiment and contained 5.9% long chain fatty acids (**LCFA**). Corn oil (1.1%) was added to the diet to mimic a distillers grains with a high, but realistic, concentration of fat. The diet for the second treatment contained 6.4% LCFA for 4 days, followed by a diet with 5.4% LCFA for 4 days, and then that cycle was repeated. The third treatment was similar to the second treatment except it contained either 7.0 or 4.8% LCFA. The concentrations of corn oil and the ratio of high fat and low fat distillers grains were altered in the diets to obtain the desired concentration of LCFA, and all diets contained the equivalent of 25% distillers grains (sum of all distillers grains plus corn oil). On average, all treatments (over the 16 day experiment) contained 5.9% LCFA.

No effects of the moderate variation treatment (i.e., 5.4% and 6.4% LCFA) were observed compared to control cows for DM intake and milk yield (Figure 3). Cows on the high variation treatment produced less milk and had lower DM intake (Figure 3) over the 16 day experiment; however, the effects were not expressed until cows experienced the second cycle of high variation. In other words, the negative effects of extreme diet variation in LCFA concentration appeared to be cumulative. Milk composition was not affected by treatment, but milk fat concentration was quite low on all treatments (2.4%), suggesting that all diets contained excessive amounts of polyunsaturated fatty acids.

Transient change in silage DM concentrations

Transient changes in silage DM concentrations can occur because of weather events (e.g., unprotected silage in a bunker gets rained upon); therefore, this experiment (McBeth et al., 2013) was conducted to determine whether short term changes in silage DM affected cows and whether as-fed rations should be adjusted to account for the short term change in silage DM.

One treatment was a consistent diet over the 21 day experiment that contained 55% forage (2/3 alfalfa silage and 1/3 corn silage) on a DM basis and 45% concentrate. The second treatment was the same as the first treatment except during two 3-day bouts when wetted silage was fed. Wetted silage was made by adding enough water to the mix of alfalfa and corn silages to reduce its DM concentration by 10 percentage units. During those two 3-day bouts (days 3, 4, and 5 and days 12, 13, and 14 of the experiment), the wetted silage replaced the normal silage on an equal as-fed basis. Because the silage was wetter, the forage-to-concentrate ratio during the bouts for this treatment was reduced to 49:51 on a DM basis. During the bouts, the NDF concentration was lower for this treatment and the starch concentration was higher (Table 2). The third treatment was the same as the second treatment except that during the bouts, the amount of as-fed forage offered was increased to maintain the same forage-to-concentrate ratio and concentrations of NDF and starch (on a DM basis) as the control diet. Over the 21-day experiment, DM intake of the 2 wet silage treatments did not differ from the control (Table 2), but milk yield was higher than control for the unbalanced, wetted silage treatment. The increased milk yield was likely in response to the increased concentrate in the diet during the bouts. Milk yield was the same for cows fed the control or fed the diet with wetted silage that was reformulated to account for the added water. **In this experiment, cows were offered excess feed so that when the wetter diets were fed, the cows did not run out of feed.** This approach was likely the reason that we did not observe any negative effects. When fed the wetted silage, the as-fed intake of the cows increased immediately (Figure 4); this could not have happened if excess feed was not offered to the cows. As-fed intake continued to increase during the second day of the bouts, and it was not until the second day of feeding wetted silage that DM intake returned to normal for those cows.

An interesting finding of this experiment, which also has practical application, is the intake pattern of cows when they switched from the wetted silage back to their normal diet. The day following each bout (this was consistent for all periods, all bouts and both wetted silage treatments), DM intake was higher than control. Cows appeared to consume about the same amount of as-fed feed on the day when they returned to the normal DM silage, but because the diet was drier, DM intake increased compared to control. This implies that extra feed should be offered to cows when they are switched from wet silage back to the normal silage. Research from the US Dairy Forage Research Center using similar treatments found that DM intake dropped by as much as 5 lbs/day when cows were first fed wetted silage, which resulted in a decrease in daily milk yield of up to 6 lb (Boyd and Mertens, 2010). In that study, the amount of feed offered **was not increased** when wetted silage was fed and the cows ran out of feed. From our study, rebalancing diets for a short term (a few days) change in silage DM is not necessary. However, increasing the amount of feed offered is probably important to maintain production, and excess feed should be offered for a day or two after the silage DM returns to normal.

Extreme day-to-day variation in forage quality

Because of variation within fields, the composition of a mixed legume-grass silage can be extremely variable. This experiment (Yoder, 2013; Yoder et al., 2013) was conducted to evaluate the effects of extreme daily variation in forage quality (this includes concentrations of NDF, CP, and the alfalfa:grass ratio) and variation in longer term changes in the forage-to-concentrate ratio. The first treatment was the control and forage quality was as consistent as possible day-to-day. The second treatment (Variable) had a constant forage-to-concentrate ratio (same as the control), but the ratio of alfalfa to grass varied daily in a random pattern. The third treatment in this experiment evaluated the effects of ‘nutritionist-induced variation’ by making

diet changes based on an unrepresentative sample. This treatment was called ‘Over-reacting’ because it mimicked reformulating a diet based on inadequate data (i.e., a single sample). A single sample rarely reflects the true composition of a feed, and when formulating diets, the use of an average based on at least 2 samples (4 samples are better) is strongly recommended.

On average, over the 21-day period, all treatments were equal in percent forage, alfalfa-to-grass ratio, NDF, CP, and starch, but the Variable treatment and the Over-reacting treatment had much greater variation in nutrient composition than the control. The concentrations of forage NDF in the diets are shown in Figure 5. Concentrations of other nutrients also varied (data not shown). For example, CP also varied greatly in the Variable treatment and starch varied similar to NDF, but concentrations varied in the opposite pattern as did NDF for the Over-reacting treatment.

Over the 21-day experimental period, average DM intake and milk yield was greater for cows on the Over-reacting treatment (Figure 6). Cows on the Variable treatment consumed similar amounts of DM and produced similar amounts of milk compared to the Control (milk composition was not affected by any treatment) over the 21-day experiment. Daily within cow variation in milk yield and DM intake were significantly greater for cows on the Variable and Over-reacting treatments compared with Control. Based on other measurements we made, a likely reason that high producing cows were not negatively affected by extreme daily variation in forage quality was because diet variation was mitigated by transient mobilization of body energy. On days when cows were fed high concentrations of grass (i.e., lower quality forage), DM intake was reduced but cows mobilized energy to maintain milk yield. On days when cows were fed a better diet (more alfalfa and less grass), cows ate more and produced more milk. This suggests that over a longer time period (this experiment only

lasted 3 weeks), a highly variable diet could reduce body condition which can have long term negative impacts on reproduction and production. Body condition was not affected in our experiment, but the experiment was probably too short for a change in body condition to be detectable.

Conclusions

The composition of diets fed to lactating cows is not constant. However, many cows appeared to handle substantial day-to-day variation in nutrient composition without significant negative effects. This may mean that a 24 hr day is not the correct periodicity for assessing variation. Some of our data suggest that a period of 3 to 5 days may be more appropriate. In other words, if nutrient composition differed between 2 successive 3-day periods, cows might be more likely to respond to that variation. We have some evidence that diet variation may have cumulative negative effects and that over a longer term (months), negative effects of variation may increase. A key management factor that appeared to reduce the effects of variation was ensuring that cows had access to adequate feed on all days. If the diet changes and cows need to consume more feed (e.g., the diet becomes wetter) or the diet changes and the cow can consume more feed (e.g., diet changes from a higher concentration of NDF to a lower concentration), feed must be available to allow the cow to compensate. If this compensation cannot occur, the effects of variation would likely be exacerbated. Although providing excess feed may mitigate some negative effects of variation, it will also increase feed costs.

References

Archibeque, S.L., H.C. Freetly, N.A. Cole, and C.L. Ferrell. 2007. The influence of oscillating dietary protein concentrations on finishing cattle. II. Nutrient retention and ammonia emissions. *J. Anim. Sci* 85:1496-1503.



- Armentano, L., and C. Leonardi. 2003. Problems with sorting in total mixed rations. Proc. Tri-State Dairy Nutr. Conf., Ft. Wayne, IN. The Ohio State University, Columbus. Pgs. 87-99.
- Belyea, R.L., K.D. Rausch, T.E. Clevenger, V. Singh, D.B. Johnston, and M.E. Tumbleson. 2010. Sources of variation in composition of DDGS. Anim. Feed Sci. Tech. 159:122-130.
- Boyd, J., and D.R. Mertens. 2010. Abrupt changes in forage dry matter of 1 to 3 days affect intake and milk yield in early lactation dairy cows. J. Dairy Sci. 93(E-Suppl. 1):514. (Abstr.)
- Buckner, C.D., M.F. Wilken, J.R. Benton, S.J. Vanness, V.R. Bremer, T.J. Klopfenstein, P.J. Kononoff, and G.E. Erickson. 2011. Nutrient variability for distillers grains plus solubles and dry matter determination of ethanol by-products. Prof. Anim. Sci. 27:57-64.
- Cole, N.A. 1999. Nitrogen retention by lambs fed oscillating dietary protein concentrations. J. Anim. Sci. 77:215-222.
- Kertz, A.F. 1998. Variability in delivery of nutrients to lactating dairy cows. J. Dairy Sci. 81:3075-3084.
- Leonardi, C., and L.E. Armentano. 2003. Effect of quantity, quality, and length of alfalfa hay on selective consumption by dairy cows. J. Dairy Sci. 86:557-564.
- McBeth, L.J., N.R. St-Pierre, D.E. Shoemaker, and W.P. Weiss. 2013. Effects of transient variation in silage dry matter concentration on lactating dairy cows. J. Dairy Sci. 96:(accepted Feb. 20, 2013).
- Rutter, S.M., R.J. Orr, N.H. Yarrow, and R.A. Champion. 2004. Dietary preference of dairy cows grazing ryegrass and white clover. J. Dairy Sci. 87:1317-1324.
- St-Pierre, N.R., and D. Gerstner. 2005. Effects of daily variation in dietary protein concentrations on milk production in mid-lactation dairy cows. J. Dairy Sci. 88 (Suppl. 1):91 (Abstr.).
- Weiss, W.P., D.E. Shoemaker, L.R. McBeth, and N.R. St-Pierre. 2013. Effects on lactating dairy cows of oscillating dietary concentrations of unsaturated and total long-chain fatty acids. J. Dairy Sci. 96:506-514.
- Weiss, W.P., D. Shoemaker, L.R. McBeth, P.S. Yoder, and N.R. St-Pierre. 2012. Within farm variation in nutrient composition of feeds. Pages 103-140 in Proc. Tri-State Dairy Nutr. Conf., Ft. Wayne, IN. The Ohio State University, Columbus.
- Yoder, P.S. 2013. Effects of forage quality variation on lactating dairy cows. M.S. Thesis. The Ohio State University, Columbus, OH.
- Yoder, P.S., N.R. St-Pierre, K.M. Daniels, K.M. O'Diam, and W.P. Weiss. 2013. Effects of short term variation in forage quality and forage to concentrate ratio on lactating dairy cows. J. Dairy Sci. 96:(submitted Feb 28, 2013).

Table 1. Measures of variation in the composition of TMR fed on 50 dairy farms across the U.S..¹

	DM, %	CP, %	NDF, %	Ash, %	Sodium, %
Across farm averages ²					
Mean	48.1	17.0	33.1	7.72	0.42
SD	2.30	0.77	1.61	0.501	0.065
CV, %	4.8	4.5	4.9	6.4	15.5
Range (percentage units) ³	5.3	1.7	3.7	1.1	0.15
Within farm statistics ⁴					
Minimum CV	0.30	0.22	0.72	1.4	4.2
Maximum CV	17.2	10.7	10.1	16.5	46.9
Minimum Range	0.2	0.1	0.5	0.2	0.02
Maximum Range	16.7	3.9	7.8	3.3	0.7

¹Values are on a DM basis; DM = dry matter, CP = crude protein, NDF = neutral detergent fiber, SD = standard deviation, and CV = coefficient of variation.

²All statistics were calculated within a farm and then averaged.

³Maximum concentration minus minimum concentration measured within a farm.

⁴Data within a row are not necessarily from the same farm.

Table 2. Nutrient composition of diets with and without wetted silage and cow responses when fed those diets (McBeth et al., 2013)¹

	Control	Wet-Balanced	Wet-Unbalanced
Diet Composition ²			
Forage, %	55.0	55.0	48.8
DM, %	66.2	60.7	63.9
NDF, %	30.9	30.9	29.3
Forage NDF, %	23.6	23.6	21.0
Starch, %	28.4	28.4	30.4
Cow Responses ³			
DM intake, lb/day	52.8	52.6	53.0
Milk yield, lb/day	86.5	87.3	87.6*
Milk fat, %	3.46	3.33*	3.41
Milk protein, %	2.79	2.79	2.81

*Values differ from control ($P < 0.05$).

¹For most of the 21 day experiment, all cows were fed the Control diet; however, during two 3-day bouts, 2 groups were fed wetted silage (normal silage with enough water added to reduce DM concentration by 10 percentage units). The as-fed amounts of silage were increased for the Wet-Balanced treatment to maintain nutrient composition similar to control. For Wet-Unbalanced, forage as-fed amounts were not adjusted.

²The diet composition shown for the 2 Wet treatments is for diets fed during the two 3-day bouts when wetted silage was fed.

³Cow responses are for the entire 21 day experimental period.

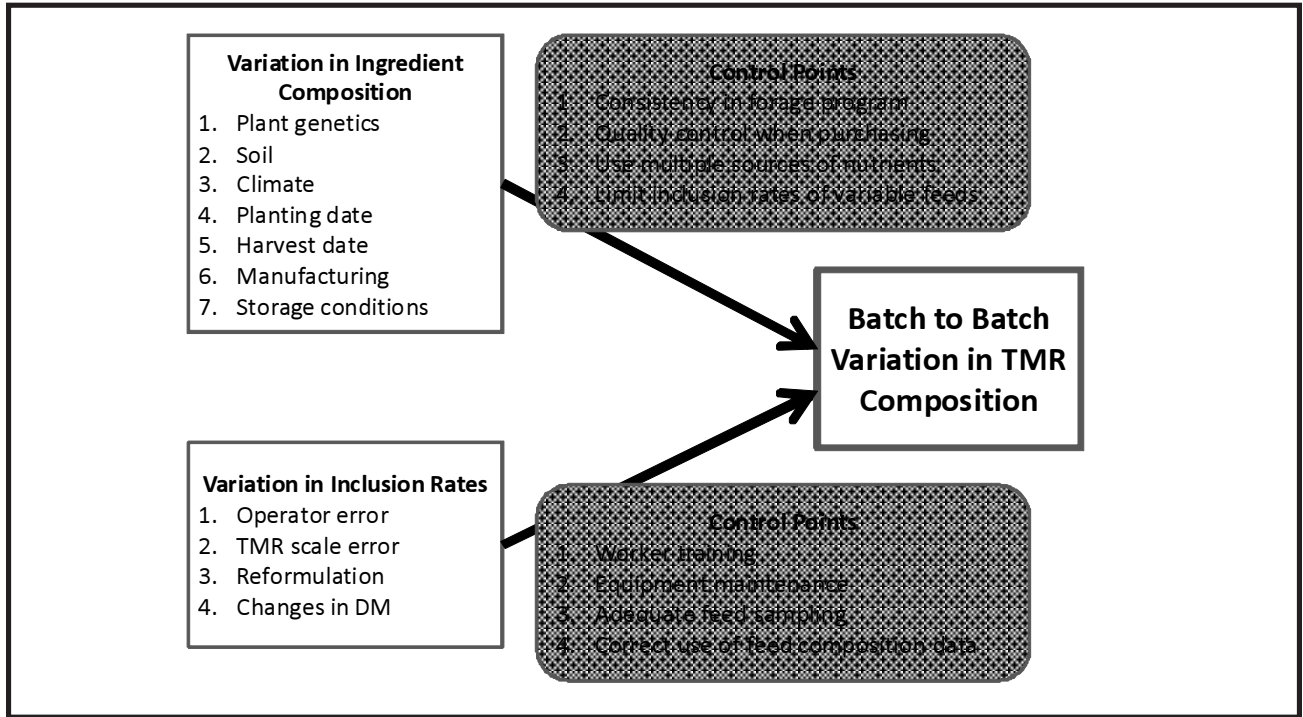


Figure 1. Factors contributing to variation in the composition of the TMR and potential control points that can be implemented to reduce the variation.

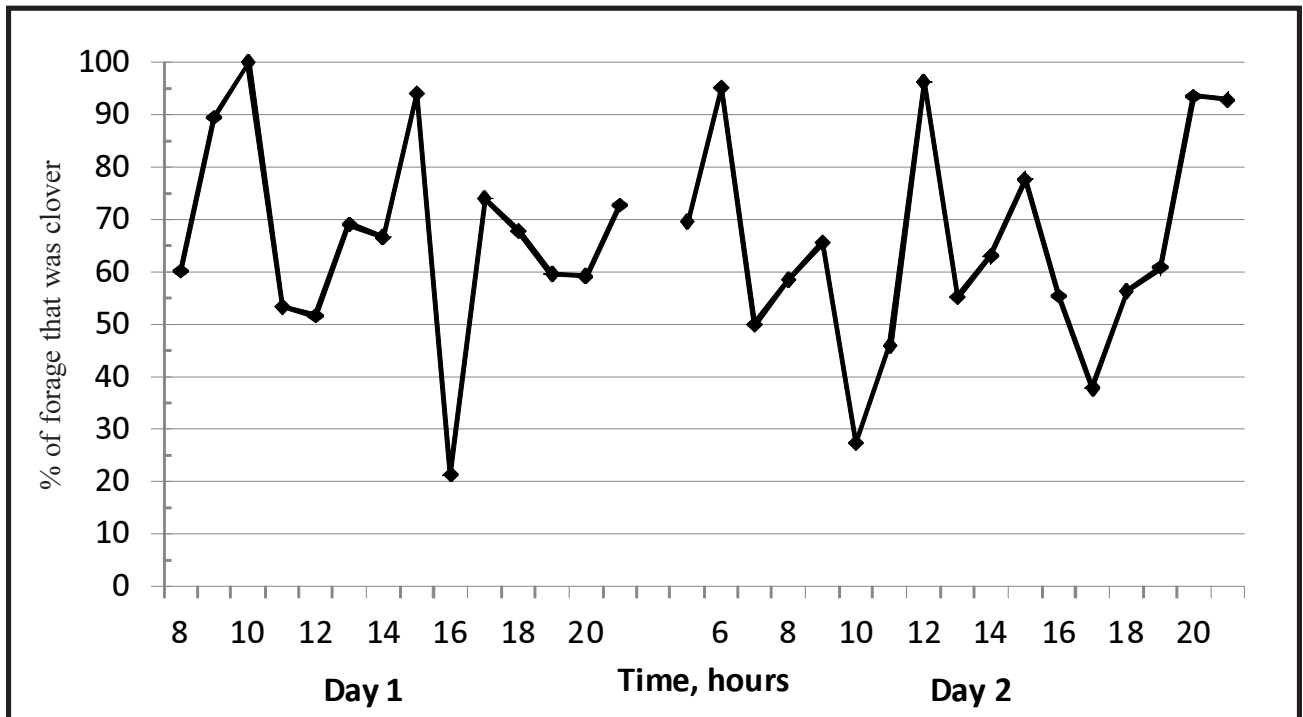


Figure 2. Proportion of white clover (the remaining proportion was ryegrass) selected by grazing dairy cows that were given access to a land area consisting of 25% white clover monoculture and 75% ryegrass monoculture. Note the high degree of hour-to-hour variation in what the cows chose to consume over a 2 day period (Rutter et al., 2004).



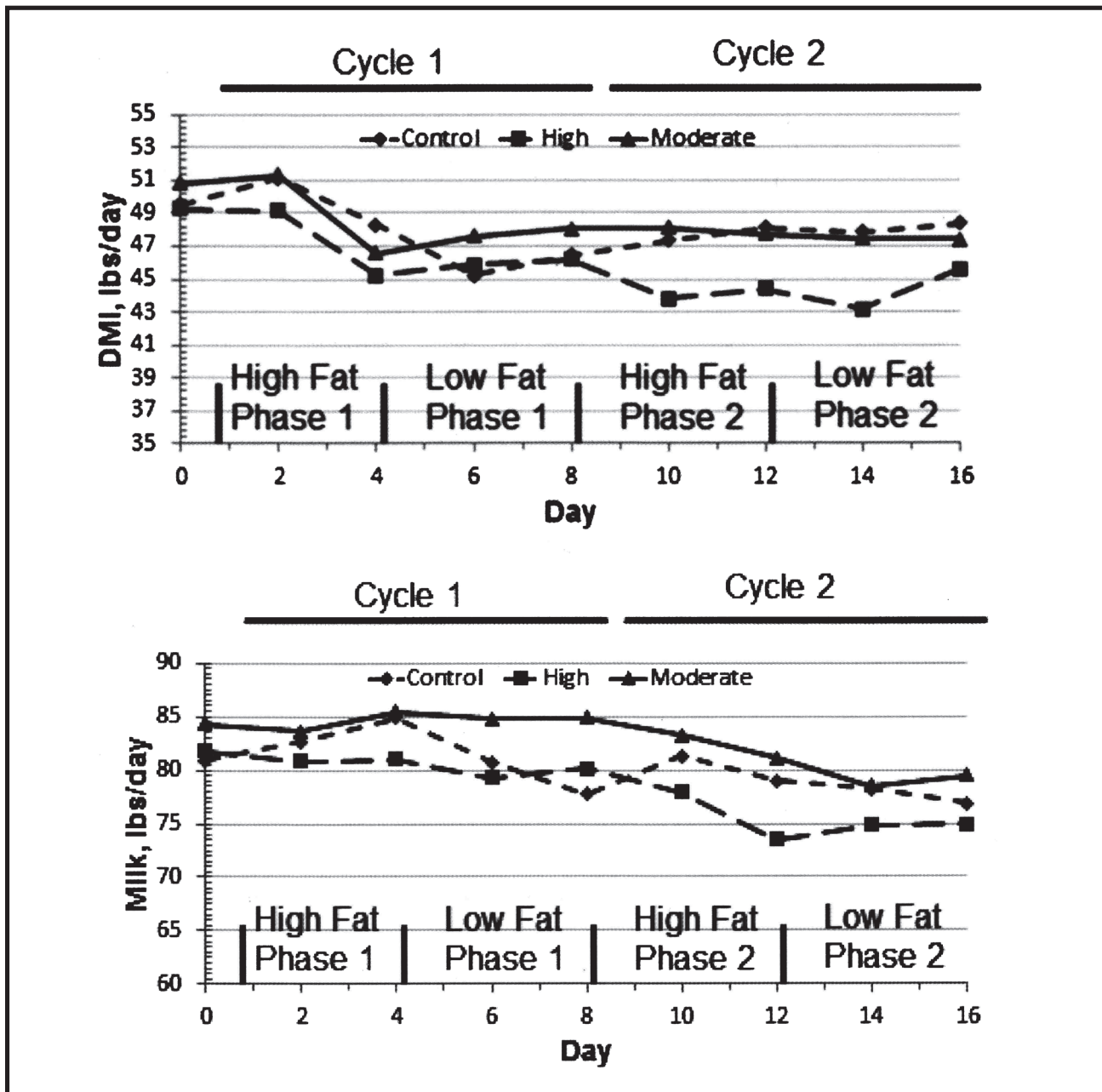


Figure 3. Effect of moderate to high variation in dietary concentrations of long chain fatty acids (Weiss et al., 2013). The control diet contained 5.9% long chain fatty acids during the 16 day experiment. The Moderate variation treatment contained 6.4 % LCFA during the high fat phases and 5.4% LCFA during the Low fat phases. The High variation diet contained 7.0% LCFA during the High fat phases and 4.8% LCFA during the Low fat phases. On average over the 16 day periods, all diets were identical.

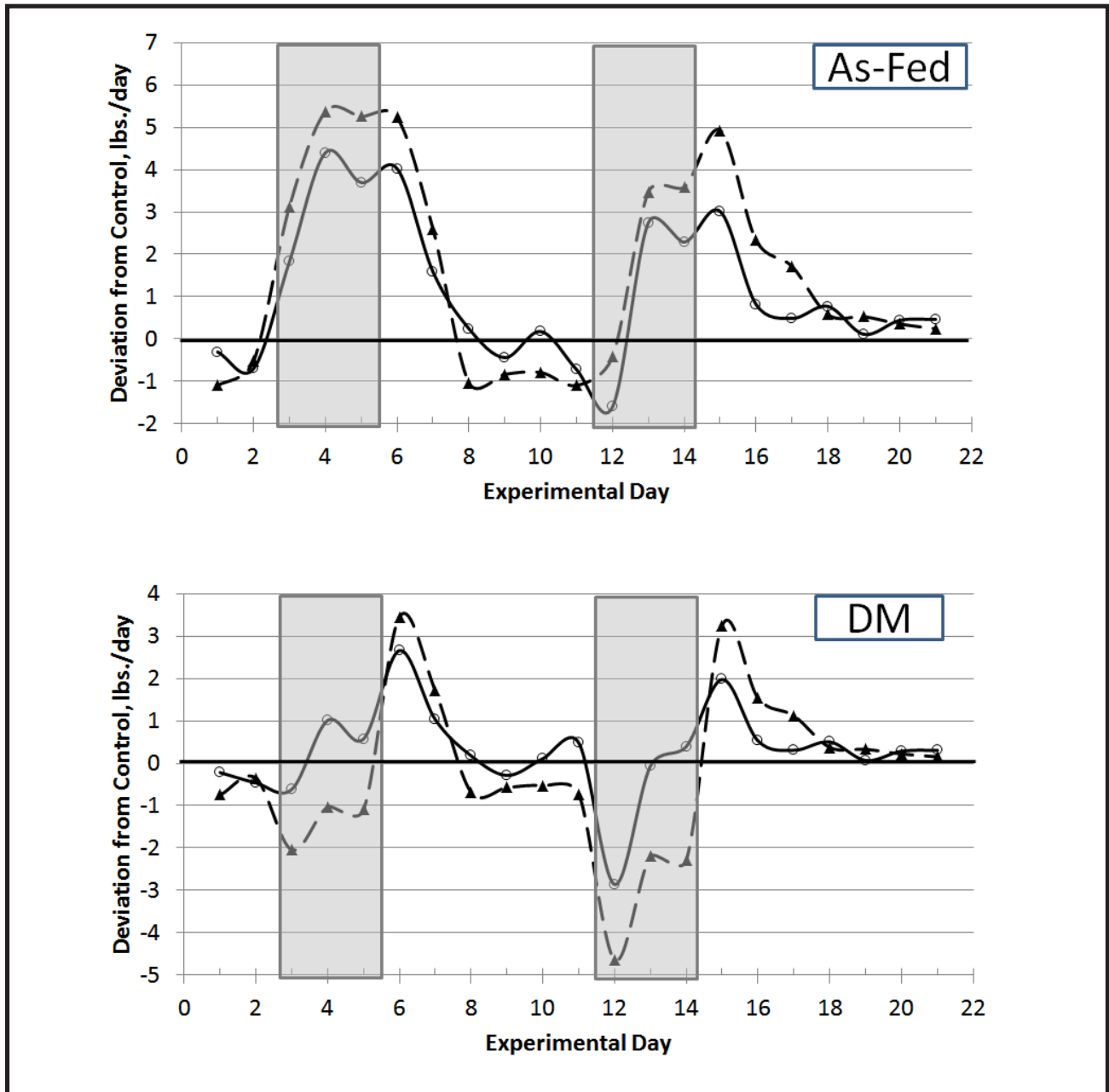


Figure 4. Deviation (Treatment – Control) of as-fed diet and DM intake by cows fed diets that were the same except during two 3-day bouts (designated by the shaded boxes) when wetted silage was fed to treatment cows (McBeth et al., 2013). One treatment with wetted silage was reformulated to maintain nutrient concentration on a DM basis (triangles with long dashes) and the other treatment was not adjusted to account for increased water concentration of the silages (circles with solid line). As-fed intake increased during both bouts for both treatments, but in the second bout, the increase was not adequate to maintain DM intake. As-fed intake was maintained after cows changed back to the control diet which resulted in increased DM intake on the day following each bout.

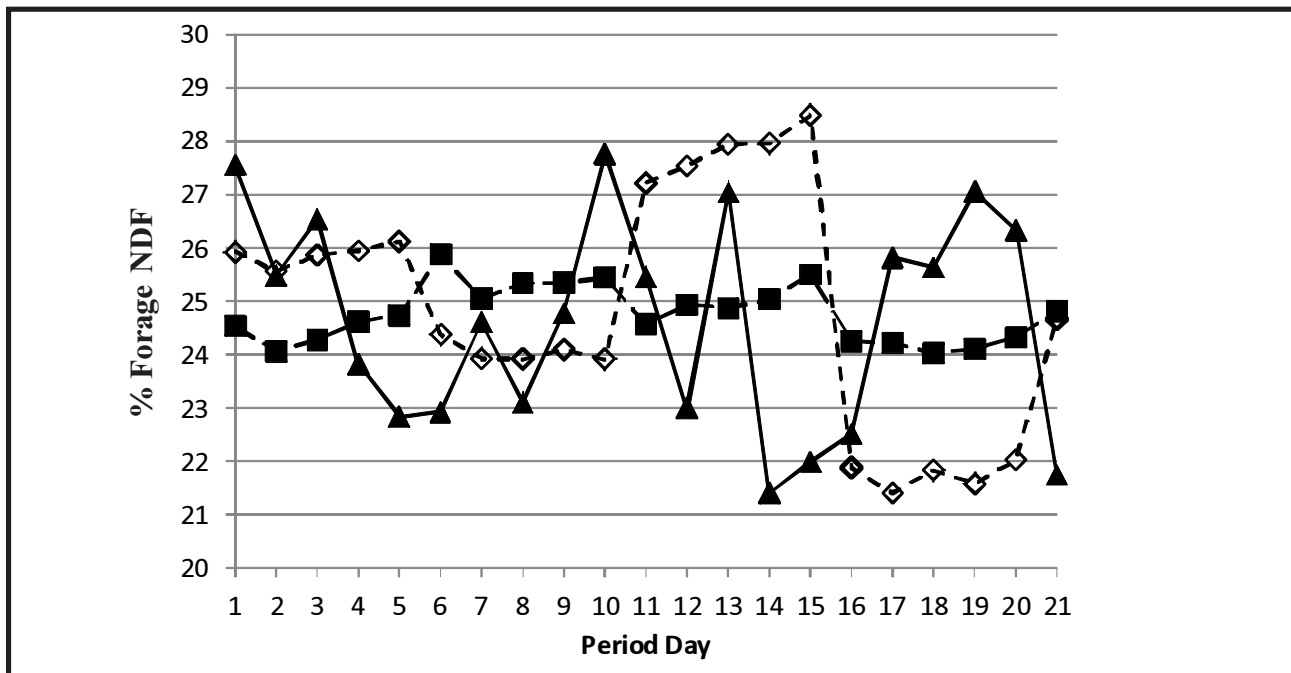


Figure 5. Actual concentrations of forage NDF in 3 diets from an experiment designed to evaluate the effects of variation in forage quality and variation in forage-to-concentrate ratio (Yoder, 2013; Yoder et al., 2013). The control diet was essentially constant in forage NDF (squares, long dashes). The ratio of grass-to-alfalfa silage changed in a random (pre-selected) pattern that resulted in random day-to-day changes in forage NDF for the Variable treatment (triangles, solid line). The forage-to-concentrate ratio (but not the grass to alfalfa ratio) changed in a cyclic pattern in the Over-reacting treatment (open diamonds, short dashes). Over the 21 day period, all diets had the same average nutrient composition and ingredient inclusion rates.

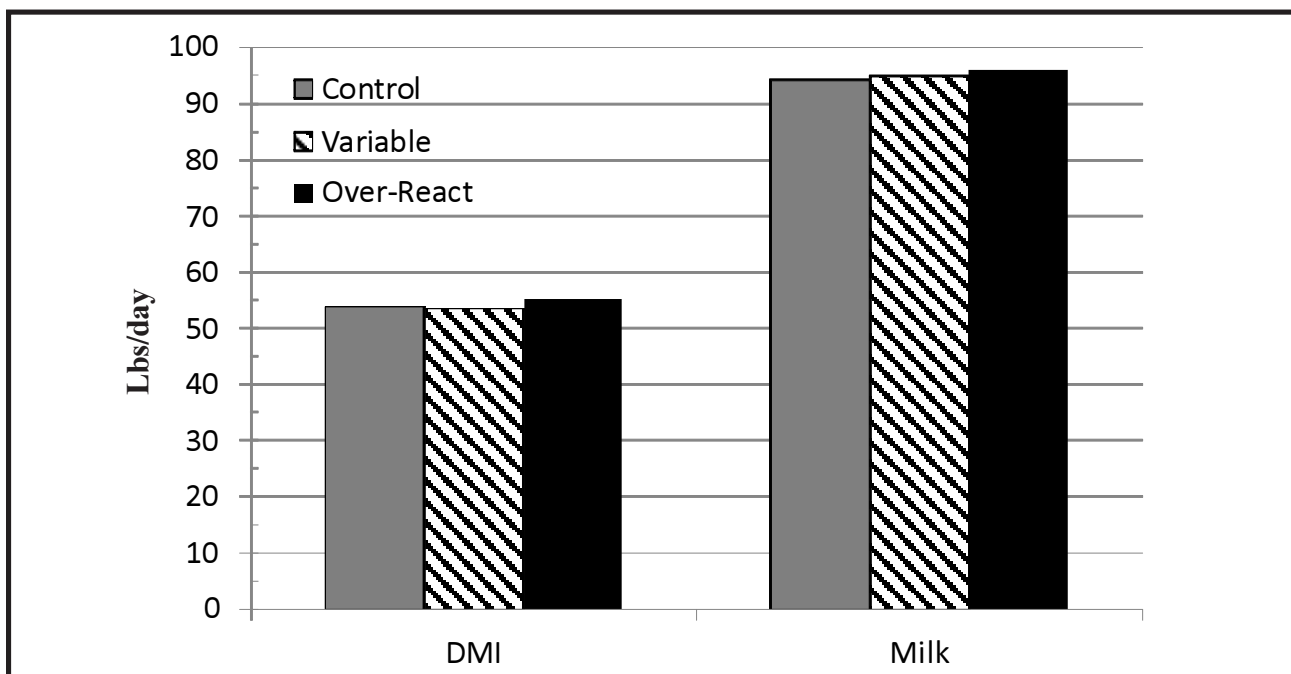


Figure 6. Milk yield and DM intake by cows fed a consistent diet (Control), a diet that varied greatly in grass-to-alfalfa ratio which caused forage NDF to vary day-to-day (Variable) or a diet in which the forage-to-concentrate ratio changed in 5 day cycles (Overreacting) (Yoder, 2013; Yoder et al., 2013).