New Insights on Feeding Post-Weaned Dairy Heifers

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Abstract

Nutrition of post-weaned heifers is important to continue to promote the growth and development of heifers. Even though there is a lot of focus placed on feeding milk-fed calves, little research information is available regarding the best strategies for feeding post-weaned dairy heifers. As feed costs are the greatest expense for raising dairy heifers, nutritional strategies to encourage growth and development, while improving feed efficiency, will be beneficial for both the animals and heifer raisers. Numerous recently conducted research studies continue to show the importance of feeding post-weaned heifers quality, grain-based diets as a way to increase growth and improve feed efficiency. Continuing to component feed heifers as they entered the growing phase was found to be advantageous as compared to switching young heifers (~300 lb) onto a TMR feeding system. In addition, continuing to feed diets containing a higher level of grain and concentrates (60:40 grain to forage ratio) was found to improve average daily gain **(ADG)** and growth, while decreasing the costs per pound of gain. Further research has shown that feeding heifers diets containing greater levels of non-fiber carbohydrates **(NFC)** resulted in greater ADG in heifers from 12 to 28 weeks of age. Diets of post-weaned heifers are important to continue to promote the proper growth and development of these heifers to ensure that they will be ready for breeding.

Introduction

Even though much emphasis continues to be placed on the nutrition of milk-fed calves, these animals continue to grow and develop. Paying close attention to the diets of post-weaned heifers helps to make sure they are growing at a rate to make sure that they will be ready for breeding and that they are efficiently utilizing the diets they are fed.

Heifer diets are often forage-based diets that are formulated with a goal of being inexpensive. As heifers are fed for approximately 2 years without any economic return, they do comprise a significant cost for dairy operations, and heifers are usually either the second or third greatest expense for dairy herds (Heinrichs et al., 2013). As compared to lactating cattle, dairy heifers have relatively low nutrient requirements and are often fed diets with higher forage levels. However, young heifers require greater dietary nutrient concentration than older heifers and, therefore, need to be fed differently.

Nutrition of dairy heifers is often talked about as a whole without referring to the age and growth stage of the heifer. Similar to lactating cows in various stages of lactation, the nutrient requirements of dairy heifers vary substantially during their 2 years of development. Although milk-fed calves have obviously different feed requirements, the nutrient requirements of

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heifers continue to change, especially over the 6 months after weaning. It is important to keep in mind that calves recently weaned have very different nutrient requirements from year-old heifers, and thus, need to be fed differently. Starter intake does help to promote the growth and development of the rumen in calves, but making the assumption that weaned calves are fully functional ruminants is not correct. Therefore, continuing to pay close attention to how post-weaned heifers are fed will allow for the rumen to continue to develop and will maximize the growth and development of these heifers.

Feeding Post-Weaned Heifers

Grain and forage ratios

In most dairy systems today, calves are fed ad libitum amounts of palatable grain-based starters within a few days of birth. As calves grow, they continue to increase their starter intake until they are to the point where they are able to consume enough nutrients from the starter to support their growth without consuming milk. Once calves are weaned, their starter intake continues to increase substantially to make up for the nutrients that are no longer being consumed through milk and to cover the increased nutrient needs of the calf as they continue to grow. At this time, calves are often fed a diet that consists of only starter or starter and some forage. The timing as to when calves should begin to receive forage, the type of forage they should receive, and how much of that forage they should be given is still of some debate. Some recommendations are that calves do not need to receive any forage until a couple of weeks after weaning, though there is some evidence that having some forage available at weaning may be beneficial (Bach, 2011). In addition, information as to how to continue transitioning these heifers to higher forage diets has been even less available.

Research was conducted at Purdue University to look at different grain-to-forage ratios to help determine the best strategy for feeding post-weaned dairy heifers. Heifers began the study when they were approximately 330 lb and 4.5 months of age and were assigned to diets containing either 80, 60, or 40% concentrate (DM basis) for 56 days before abruptly being switched to a common diet that was 40% concentrate.

In this study, increasing grain inclusion from 40 to 80% of the dietary DM resulted in a linear increase in BW (Table 1). Total BW gain during the treatment period averaged 76.8, 104.9, and 136.0 lb for heifers fed 40:60, 60:40, or 80:20, respectively; whereas, total gain on the common diet averaged 108.2, 106.9, and 96.4 lb for heifers previously fed 40:60, 60:40, or 80:20, respectively. Average daily gain was improved overall for heifers fed 80:20 during the treatment period compared with heifers fed 40:60 or 60:40, though following a diet change, ADG was improved for heifers previously fed 40:60 or 60:40 compared to heifers fed 80:20. Frame growth exhibited similar responses to those observed for BW and ADG. Hip heights, heart girth circumference, and body condition score linearly increased with increasing grain inclusion ($P < 0.01$) during the treatment period, resulting in higher growth overall during the study for heifers fed 80% grain during the treatment period. Peri et al. (1993) reported increased BW for dairy heifers fed ad libitum compared to restricted energy diets. However, Buskirk et al. (1996) fed early-weaned beef heifers either a moderate- or high-energy diet and reported similar ADG and skeletal growth, most likely due to increased intake for heifers fed the moderate-energy diet, resulting in similar energy intake between treatments.

Feed costs averaged $0.11, 0.12, and 0.13/lb of DMI for heifers fed 40:60, 60:40, and

80:20, respectively, during the treatment period (Table 2). Daily feed costs per head were 44.7 and 21.9% greater for 80:20 than 40:60 and 60:40, respectively, on day 14 of the trial and subsequently increased with increased DMI. On day 56 prior to switching to a common diet, feed costs per head were 68.1 and 32.5% greater for 80:20 than 40:60 and 60:40. Feed costs per pound of ADG were lowest for 60:40 heifers over the duration of the study compared to heifers fed 40:60, though they were statistically similar to the feed costs for the 80:20 heifers. When heifers were fed 60:40 or 80:20 during the treatment period, savings were $0.24 and 0.22/lb of ADG compared to heifers fed 40:60.

This study demonstrated that feeding higher grain levels to post-weaned dairy heifers can improve growth and can actually decrease the cost of gain over higher forage diets. In addition, it reinforced that heifers fed high grain levels can be negatively impacted by abrupt changes to higher forages diets, with the heifers on the 80:20 treatment showing a definite decline in intake when they were switched to a 40:60 diet from which it took some time to recover (Figure 1).

Non-fiber carbohydrates in heifer diets

Even though previous research found that feeding higher concentrate diets improved gain and feed efficiency, the concentrate portion of the diet may be made up of a wide variety of different ingredients and nutrient compositions. Understanding the best strategies for designing the concentrate portion of the diet could further help to improve the gains and feed efficiency of dairy heifers.

Previous research has found that butyrate and propionate are the most important volatile fatty acids for developing the rumen in young heifers (Tamate et al., 1962; Lesmeister and Heinrichs, 2004). Therefore, diets that provide greater amounts of readily fermentable substrates could potentially increase the production of butyrate and propionate in the rumen and may help to further promote rumen development and increase the growth and development of heifers.

In order to evaluate the effects of the composition of the concentrate portion of the diet on heifer growth, intake, and feed efficiency, studies were conducted to look at the effects of feeding concentrates that were formulated to provide either high or low levels of non-fiber carbohydrates **(NFC)**. In the first study, heifers were fed a low NDF diet **(LNFC)**, a high NFC diet **(HNFC)**, and a low NFC diet with added fat (LNFC+) formulated to provide the same amount of Mcal of energy as the HNFC diet.

Heifers fed LNFC+ were heavier on day 56 and 112 of the study compared to heifers fed LNFC (Table 3). Heifers on the HNFC diet were intermediate and tended to be lighter on day 56 and 112 compared to heifers fed LNFC+. Overall, heifers fed LNFC+ gained 19.4 lb more BW than heifers fed LNFC during the study ($P = 0.05$). Average daily gain in the first 56 days was 14.9 and 8.9% greater for heifers fed LNFC+ compared to heifers fed LNFC ($P < 0.01$) or HNFC ($P = 0.05$), respectively. Several studies have illustrated increased growth rates with increasing energy concentration for growing dairy heifers (Radcliff et al., 1997; Davis Rincker et al., 2008), though increased body condition likely accounted for some of the differences in this study as energy intake increased.

During the first 56 days, treatment tended to affect feed efficiency **(FE)**, as heifers fed LNFC+ were 12.7% more efficient than heifers fed LNFC and 9.3% more efficient than heifers fed HNFC, with a trend ($P = 0.07$)

towards improved FE for LNFC+ from day 0 to 112 as compared to HNFC. Net efficiency of fiber utilization, whether from forage or non-forage sources, is generally lower than that of starch and fat (VandeHaar and St-Pierre, 2006), though there were not any differences between the FE of high and low NFC diets in this study. However, there was an advantage in FE when fat was added to the higher fiber diet during first half of the study when heifers were younger.

During the NFC study, heifers fed LNFC maintained the lowest cost per heifer per day throughout the study as was expected due to the high inclusion rates of by-product feeds. However, feed costs per pound of ADG were lowest for heifers fed LNFC+ compared to HNFC, resulting in a cost savings of $0.12/lb of gain (Table 4). However, feed costs per pound of ADG were similar overall among treatments. In our study, a larger proportion of the HNFC diet included corn and distillers dried grains, resulting in greater costs per ton for the grain mix, especially due to higher corn prices from the 2012 crop year. Paired with increased DMI for heifers fed HNFC, our data suggest that alternative energy sources, such as supplemental fat, may be more cost-effective for feeding growing heifers.

A second study was conducted to evaluate the effect of NFC level in the diets of post-weaned heifers after being started on either a conventional (22:20) or higher plane of nutrition (28:20) milk replacer. One of the goals of this study was to determine if how a calf was raised pre-weaning affects subsequent heifer growth and performance. In this study, animals receiving the HNFC diet had greater weight gain during the growing period from 12 to 28 weeks. Interestingly, when the animals were started on a higher plane of nutrition during the milk feeding period and subsequently fed LNFC diets, their BW gain was significantly decreased as compared to animals that were started with a conventional milk replacer program (Table 5). This study indicates that when calves are started on diets with a higher level of nutrition, maintaining a greater level of nutrition into the growing period may be even more important than when calves are started on a conventional milk feeding program.

Intake of post-weaned heifers

When formulating diets for heifers, having a knowledge of intake is important to help determine dietary concentrations needed to ensure that the animals are consuming the recommended amounts of nutrients. The current dairy NRC (2001) model utilizes only $BW^{0.75}$ and NE_m content of the diet when predicting intake of non-pregnant growing heifers and does not consider other dietary or non-dietary factors. Estimates of DMI for large breed heifers according to the dairy NRC (2001) are 2.8% of BW or less. In our research, intakes of post-weaned heifers averaged 3.0% or more of their BW when they were fed diets containing at least 60% concentrate (Figure 1).

In a study designed to look at feed delivery methods, diets formulated according to the NRC (2001) requirements for 2.0 lb/day of ADG for Holstein heifers estimated DMI of 13.6 lb/day for heifers at the conclusion of the study. Actual DMI observed at the end of the study averaged 20.6 lb/day among treatments, a 51% increase over the NRC predicted intake. While ADG was similar to NRC predictions in the current study, particularly for heifers fed using a TMR, the gross under-estimation of DMI by the model suggests factors other than dietary energy content are required for more accurate estimations of intake in heifers.

Other estimations for intake of heifers have been made. Hoffman et al. (2008)

proposed that replacement heifers will restrict their overall intake to 1.0% of BW as NDF intake; however, in the feed delivery study, NDF intake ranged from 1.3 to 1.4% of BW during the transition period and reached over 2.0% of BW during the grower period. Similarly, NDF intakes ranged from around 1.0 to over 1.6% of BW for heifers receiving different grain to forage ratios (Figure 2), suggesting that factors other than total dietary NDF have the potential to influence intake in replacement heifers. However, when just forage NDF intake was determined as a percentage of BW, heifers did not consume above 1% of BW (Figure 3), indicating that forage NDF and not total NDF may be a better estimator of intake in younger heifers.

Feed delivery methods for post-weaned heifers

Dietary composition is an important aspect of feeding heifers, but the delivery method can also have an impact when feeding heifers. A study was conducted to evaluate the effects of feeding heifers a TMR, feeding them concentrate and hay side-by-side in a feed bunk **(SBS)**, or feeding grain in a bunk and hay in a feeder **(HF)** on growth and intake of post-weaned heifers (Table 6). In this study, heifers fed using HF were significantly heavier ($P \leq 0.05$) than heifers fed using SBS from d 49 throughout the end of the study. Delivering feed using HF resulted in heifers that were, on average, 12.1 and 7.3 lb heavier than heifers fed using SBS and TMR, respectively, over the course of the study. Heifer weights at the conclusion of the grower period were 605, 576, and 575 lb for HF, SBS, and TMR, respectively.

Average daily gains did vary depending on the time period of the study, as heifers fed using a TMR had lower ADG from day 7 to 14 ($P = 0.05$) and day 14 to 21 ($P = 0.07$) compared with HF and SBS, but higher ADG compared to SBS from day 21 to 28 ($P = 0.03$). These results suggest that post-weaned heifers require more time to adjust to new diets when feeding a TMR compared with component-feeding.

During the grower period, heifers fed using HF averaged 1.1 lb/day more DMI compared with SBS and TMR ($P < 0.01$). However, heifers fed using a TMR consumed more DMI daily from day 63 to the conclusion of the study. The results of this study suggest that, along with responses in ADG, component-fed heifers maintained intake and weight gains when transitioning to a new diet, while TMR-fed heifers caught up in terms of ADG and efficiency towards the end of the transition period and throughout the grower period. This study indicates that there may be a certain point during the growth of a heifer when it is ideal to be able to switch over to feeding a TMR.

Conclusions

Using the best feeding strategies for post-weaned dairy heifers allows them to continue to meet their growth potential while reducing costs per pound of gain and reducing the overall costs of raising dairy heifers. Continuing to feed heifers high levels of grain post-weaning provides them with a digestible source of nutrients that facilitates growth and improves feed efficiency. At young ages, heifers appear to continue to need readily available energy sources as their rumen continues to develop. Realizing that post-weaned heifers are still developing and are not yet ready to be fed like cows facilitates an understanding that specific feeding strategies need to be developed to allow for optimal growth and development of these heifers.

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Table 1. Weight, skeletal measurements, and intake responses of prepubertal dairy heifers fed increasing levels of grain during the treatment period and then switched to a common diet.[1]

Item	40:60[2]	60:40	80:20	SEM	*P*-value
Body weight, lb					
day 57	369[c]	399[b]	429[a]	6	< 0.01
day 112	476[c]	505[b]	525[a]	6	< 0.01
ADG[3], lb/day					
day 0 to 56	1.37[c]	1.87[b]	2.29[c]	0.09	< 0.01
day 57 to 112	1.94[a]	1.92[a]	1.72[b]	0.06	0.07
day 0 to 112	1.65[c]	1.90[b]	2.07[a]	0.04	< 0.01
DM intake, lb/day					
day 0 to 56	9.3[c]	10.7[b]	12.7[a]	0.2	< 0.01
day 57 to 112	14.3	14.1	13.7	0.3	0.31
day 0 to 112	11.8[c]	12.4[b]	13.2[a]	0.2	< 0.01
DM intake, % of BW					
day 0 to 56	2.73[c]	2.96[b]	3.35[a]	0.044	< 0.01
day 57 to 112	3.26[a]	3.00[b]	2.80[c]	0.062	< 0.01
day 0 to 112	2.99[xy]	2.98[y]	3.07[x]	0.035	0.18
Feed efficiency[4]					
day 0 to 56	0.147[c]	0.178[b]	0.196[a]	0.008	< 0.01
day 57 to 112	0.136	0.139	0.128	0.005	0.31
day 0 to 112	0.142[b]	0.158[a]	0.161[a]	0.004	0.02
Hip height, in					
day 56	43.7[c]	44.4[b]	45.1[a]	0.1	< 0.01
day 112	45.8[c]	46.8[b]	47.2[a]	0.1	< 0.01
Heart girth, in					
day 56	51.3[b]	52.6[a]	52.9[a]	0.3	< 0.01
day 112	55.6[b]	57.1[a]	57.4[a]	0.3	< 0.01

[1]Day refers to day of experiment.
[2]Grain:forage ratio.
[3]Average daily gain.
[4]Feed efficiency expressed as lb of ADG per lb of daily DM intake.
[abc]Means with differing superscripts are significantly different at $P \leq 0.05$.
[xy]Means tend to differ at $0.10 \geq P > 0.05$.

Table 2. Daily feed costs for heifers fed increasing levels of concentrate during the treatment period (day 0 to 56 of experiment) followed by a common diet (day 57 to 112).

Item	40:60[1]	60:40	80:20	SEM	*P*-value
Daily feed cost per head[2]					
day 0 to 56	1.03[c]	1.29[b]	1.67[a]	0.024	< 0.01
day 57 to 112	1.48	1.45	1.41	0.030	0.31
day 0 to 112	1.26[c]	1.37[b]	1.54[a]	0.018	< 0.01
Cost of gain[3]					
day 0 to 56	0.96[a]	0.73[b]	0.73[b]	0.061	0.03
day 57 to 112	0.82	0.79	0.87	0.052	0.62
day 0 to 112	0.89[a]	0.76[b]	0.80[ab]	0.040	0.10

[1]Grain:forage ratio.
[2]All values given in US dollars ($).
[3]$/lb of average daily gain.
[abc]Means with differing superscripts are significantly different at $P \leq 0.01$.

Table 3. Weight, skeletal measurements, and intake responses of prepubertal dairy heifers fed diets containing high non-fiber carbohydrate (HNFC), low NFC (LNFC), or LNFC with added fat (LNFC+) grain fractions.

					P-value[1]	
Item	HNFC	LNFC	LNFC+	SEM	T	T×S
BW[2], lb						
day 56	438[ab,y]	431[b]	448[a,x]	4	0.02	--
day 112	552[ab,y]	544[b]	563[a,x]	4	<0.01	--
ADG[3], lb/day						
day 0 to 56	2.14[b]	2.03[b]	2.34[a]	0.06	0.02	0.01
day 56 to 112	2.05	2.01	2.05	0.07	0.86	< 0.01
day 0 to 112	2.09[ab]	2.01[b]	2.21a	0.06	0.13	< 0.01
DM intake, lb/day						
day 0 to 56	12.7	12.6	12.9	0.1	0.45	0.01
day 56 to 112	16.5[a]	15.3[b]	15.4[b]	0.4	0.06	< 0.01
day 0 to 112	14.6[x]	14.0[y]	14.2[xy]	0.2	0.15	< 0.01
DM intake, % of BW						
day 0 to 56	3.26	3.24	3.22	0.04	0.73	0.03
day 56 to 112	3.25[a]	3.03[b]	2.96[b]	0.05	< 0.01	< 0.01
day 0 to 112	3.25[a]	3.14[b]	3.09[b]	0.03	< 0.01	< 0.01
NDF intake, % of BW						
day 0 to 56	1.15[b]	1.42[a]	1.42[a]	0.02	< 0.01	< 0.01
day 56 to 112	1.34[b]	1.41[a]	1.39[a]	0.02	0.09	< 0.01
day 0 to 112	1.25[b]	1.42[a]	1.41[a]	0.01	< 0.01	< 0.01
Feed efficiency[4]						
day 0 to 56	0.166[ab,y]	0.161[b]	0.181[a,x]	0.006	0.06	0.20
day 56 to 112	0.123	0.132	0.133	0.007	0.52	0.10
day 0 to 112	0.144[y]	0.146[xy]	0.157[x]	0.004	0.12	0.07
Hip height, in						
day 56	44.8[ab]	44.7[b]	45.1[a]	0.1	0.06	--
day 112	47.6[a]	47.2[b]	48.0[a]	0.1	< 0.01	--

[1]T = treatment effect; T×S = treatment × time interaction.
[2]Body weight; day refers to day of experiment.
[3]Average daily gain.
[4]Feed efficiency expressed as lb of ADG per lb of daily DM intake.
[abc]Means differ at $P \leq 0.05$.
[xy]Means tend to differ at $0.10 \geq P > 0.05$.

Table 4. Daily feed costs for heifers fed diets containing high non-fiber carbohydrate (HNFC), low NFC (LNFC), or LNFC with added fat (LNFC+) grain fractions.[1,2]

Item	HNFC	LNFC	LNFC+	SEM	*P*-value
Daily feed cost per head					
day 0 to 56	1.63[a]	1.49[c]	1.58[b]	0.02	< 0.01
day 57 to 112	1.83[a]	1.59[b]	1.65[b]	0.04	< 0.01
day 0 to 112	1.73[a]	1.54[c]	1.61[b]	0.02	< 0.01
Cost of gain[3]					
day 0 to 56	0.84[a]	0.81[ab]	0.72[b]	0.04	0.09
day 57 to 112	1.08	0.95	0.98	0.11	0.70
day 0 to 112	0.96	0.88	0.85	0.06	0.39

[1]All values given in US dollars ($).
[2]Day refers to day of experiment.
[3]$/lb of average daily gain.
[abc]Means with differing superscripts are significantly different at $P \leq 0.05$.

Table 5. Weight and skeletal growth responses of dairy heifers and steers at 28 wks of age fed a milk treatment (MILK) of either conventional milk replacer (CONV) or high nutrition plane milk replacer (HIGH) and fed a grower diet (GRWR) of high non-fiber carbohydrate (HNFC) or low NFC (LNFC) post-weaning grower diets from 12 to 28 wk of age.

	CONV		HIGH			*P*-value[1]		
Item	HNFC	LNFC	HNFC	LNFC	SEM	MILK	GRWR	MILK × GRWR
BW[2], lb								
28 wk[3]	516[a]	503[ab]	522[a]	495[b]	8	0.88	< 0.01	0.04
ADG[4], lb/day								
0 to 28 wk	2.12	2.03	2.14	1.98	0.05	0.95	0.01	0.49
Hip height, in								
28 wk	47.6	47.2	47.4	47.3	0.2	0.91	0.24	0.60
Hip width, in								
28 wk	13.9[ab]	13.9[ab,x]	14.1	13.7[b,y]	0.1	0.85	0.15	0.08
Heart girth, in								
28 wk	56.1	56.5	56.7	56.5	0.4	0.34	0.90	0.59

[1]MILK = Effect of pre-weaning milk treatment; GRWR = effect of post-weaning diet; and MILK × GRWR = interaction of milk treatment vs. post-weaning diet effects.
[2]Body weight.
[3]Weeks of age.
[4]Average daily gain.
[ab]Means with differing superscripts significantly differ at $P \leq 0.05$.
[xy]Means with differing superscripts tend to differ at $0.10 \geq P > 0.05$.

Table 6. Body weight, intake, and skeletal measurements of prepubertal dairy heifers fed common diets using different feed delivery methods.[1]

Item	HF	SBS	TMR	SEM	P-value
Body weight, lb					
day 28[2]	397	392	388	4	0.37
day 133	605[a]	576[b]	575[b]	4	<0.01
ADG[3], lb/day					
day 0 to 28	2.29	2.09	1.96	0.12	0.21
day 29 to 133	2.05[a]	1.83[b]	1.85[b]	0.06	0.06
day 0 to 133	2.09[a]	1.90[b]	1.87[b]	0.06	0.02
Hip height, in					
day 133	47.6	47.8	47.9	0.3	0.81
Heart girth, in					
day 133	58.8[a,x]	57.8[b]	58.1[b,y]	0.3	0.03
DMI[4], lb/day					
day 0 to 28	9.57	9.08	9.72	0.22	0.15
day 29 to 133	18.04[a]	17.00[b]	16.96[b]	0.21	<0.01
day 0 to 133	16.16[a]	15.26[b]	15.34[b]	0.18	<0.01
Feed efficiency[5]					
day 0 to 28	0.224[a]	0.228[a]	0.188[b]	0.010	0.03
day 29 to 133	0.114	0.111	0.109	0.003	0.58
day 0 to 133	0.124[ab]	0.127[a]	0.115[b]	0.004	0.10

[1]HF = hay feeder; SBS = side-by-side; TMR = total mixed ration; and SEM = standard error of the mean.
[2]Day of study.
[3]Average daily gain.
[4]Dry matter intake.
[5]Feed efficiency expressed as lb of ADG per lb of daily DMI.
[ab]Means differ at $P < 0.05$.

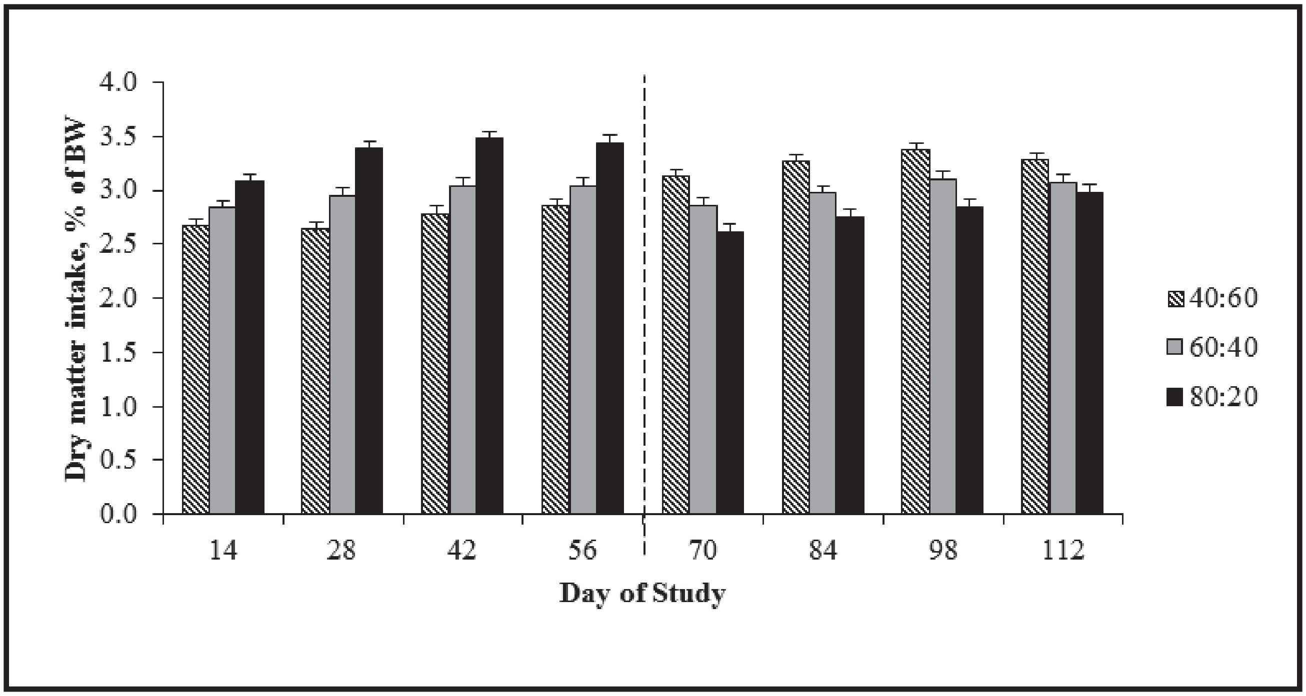

Figure 1. Effects of increasing grain inclusion during the treatment period, followed by a rapid switch to a common diet on DM intake as a percentage of BW over time. Vertical dashed line indicates time of diet switch relative to day of study. Treatment differences were not apparent overall ($P = 0.18$); however, a treatment × time interaction was observed ($P < 0.01$), as heifers fed 40:60 consumed the least amount of DM during the treatment period as a % of BW compared to heifers fed 80:20, but consumed the most DM during the grower period compared to 60:40 and 80:20.

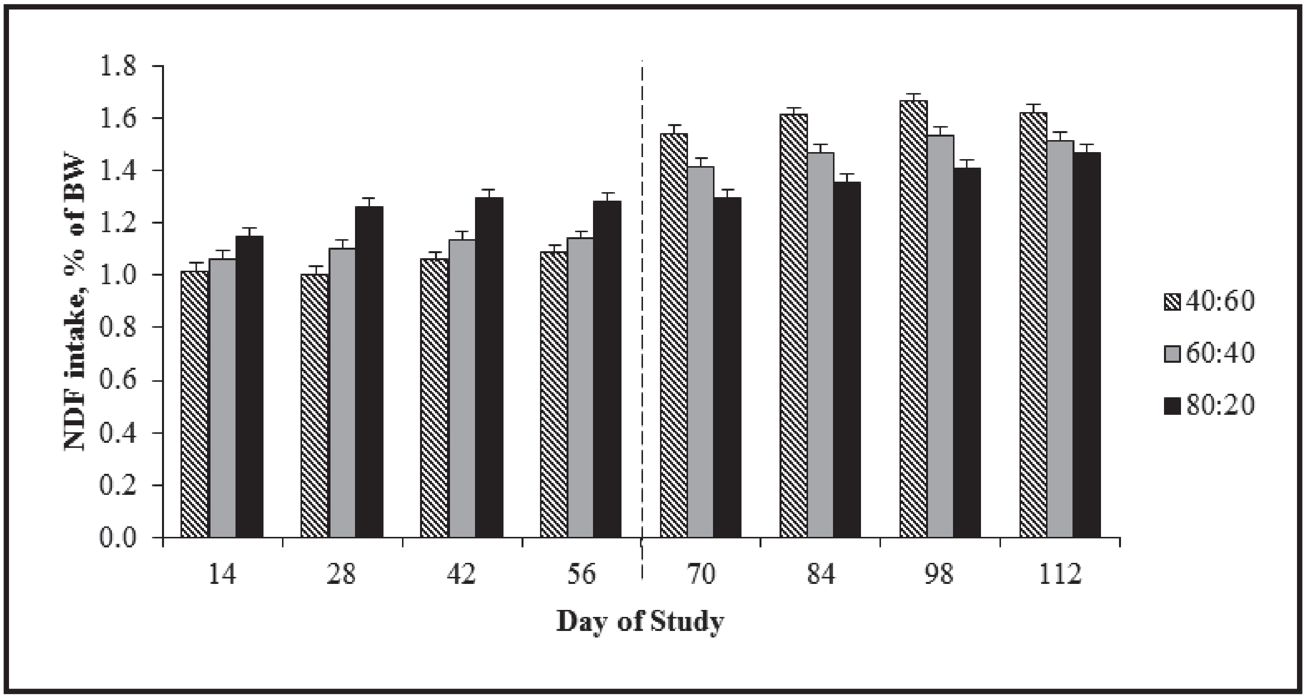

Figure 2. Effects of increasing grain inclusion during the treatment period followed by a rapid switch to a common diet on NDF intake (DM basis) as a percentage of BW over time. Vertical dashed line indicates time of diet switch relative to day of study. There were no overall treatment differences (P = 0.46); however a treatment × time interaction was observed (P < 0.01), as heifers fed 40:60 consumed the least amount of total NDF during the treatment period as a % of BW compared to heifers fed 80:20, but they consumed the most total NDF during the grower period compared to 60:40

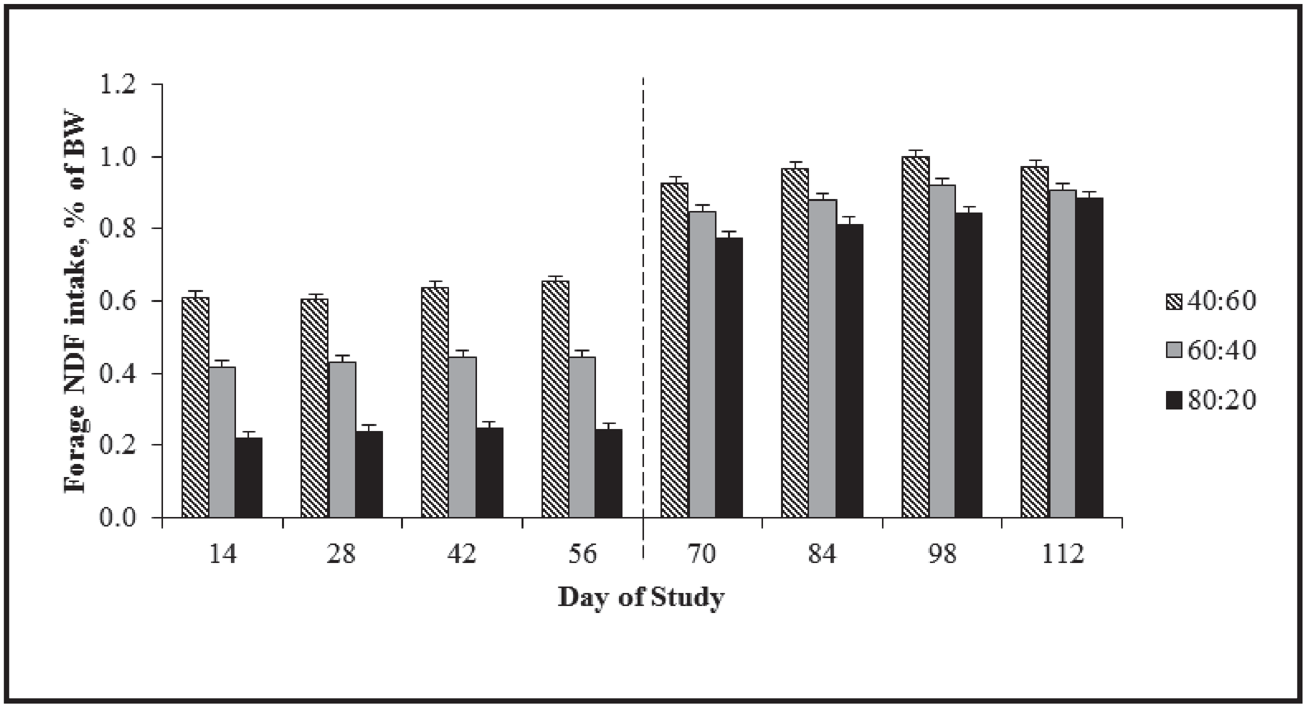

Figure 3. Effects of increasing level of concentrate inclusion during the treatment period followed by a rapid switch to a common diet on forage NDF intake (DM basis) as a percentage of BW over time. Vertical dashed line indicates time of diet switch relative to day of study. Forage NDF intake increased linearly overall as grain inclusion was reduced in the treatment period ($P < 0.01$), and a treatment × time interaction was also observed overall ($P < 0.01$). As expected, forage NDF intake linearly increased as grain inclusion decreased; however, forage NDF intake was greatest throughout the grower period for heifers previously fed 40:60.