The Potential to Limit Feed Dairy Replacement Heifers

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Introduction

The goals of a dairy replacement management program are to rear heifers at low economic and environmental costs without compromising future lactation performance. To meet these objectives, heifers are commonly fed diets containing high fiber forages (MPS, 2003), which meet the low energy requirement (NRC, 2001) of replacement heifers. Feeding heifers low energy, high fiber forages also helps minimize over-conditioning at calving which can be detrimental to lactation performance (Hoffman et al., 1996). Total feed costs and feed efficiency are, however, often over-looked with feeding heifers diets containing predominately high fiber forages. Historically, research (Hoffman et al., 1996; Van Amburgh et al.; 1998, Radcliff et al., 2000) has been focused on feeding heifers higher energy diets to reduce calving age (recommended (22 to 24 months) as a methodology to shorten the length of the rearing period and correspondingly reduce feed costs. Although this strategy has the potential to lead to an earlier return on feed investment, decreasing the calving age frequently results in a decrease in lactation performance (Hoffman et al., 1996; Van Amburgh et al., 1998; Radcliff et al., 2000). Another strategy to reduce heifer feed costs is to feed higher energy diets and limit the amount of the diet fed, controlling average daily gain **(ADG)** which could effectually yield a calving age and body condition score similar to feeding high forage diets. This management strategy will be referred to as limit feeding for the remainder of this paper. Limit feeding has the potential to reduce feed costs, increase feed efficiency, and decrease fecal excretion, while preserving the rearing period time course which to date has been difficult to alter without negative health and production effects. This paper will review biological and behavioral issues associated with limit feeding dairy replacement heifers.

Pseudo Limit-feeding Research

Limit feeding ruminants is not new or novel. Limit-feeding strategies have been successfully employed with ruminants, such as beef cows, (Loerch, 1996), ewes (Susin et al. 1995), and beef heifers (Wertz et al., 2001) on steers (Loerch 1990). Likewise, limit feeding dairy replacement heifers is not new or novel and has been a research methodology in a number of investigations. What is different about these investigations is that limit feeding was not the central hypothesis, rather limit feeding was merely a methodology to investigate a related hypothesis. The author has arbitrarily classified these research projects as pseudo limit-feeding research.

For example, Lammers et al. (1999) used limit-feeding as a method to control growth rates of prepubertal Holstein heifers to investigate effects of prepubertal growth rates on lactation performance. Differing prepubertal growth rates were achieved by offering different amounts of dry matter **(DM)** of a single diet [(16.0% CP and 1.21 Mcal/lb of

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metabolizable energy, **(ME)**]. Prepubertal ADG were 1.54 and 2.20 lb/day, thus the 1.54 lb/day treatment was commissural with limit feeding. Heifers limit fed to grow 1.54 lb/day produced 7.1% more milk than heifers fed near ad libitum (2.2 lb ADG, which was attributed to differences in prepuberty mammary development and thus the central hypothesis of the experiment. Lammers et al. (1999) observed no negative effects of limit feeding on either body weight **(BW)**, calf birth weight, or dystocia index.

North Dakota researchers (Park et al., 1998; Ford and Park, 2001) have hypothesized that dietary energy restriction, followed by realimentation, stimulates rapid and greater expression of mammary tissue, resulting in improved milk production. The work has demonstrated alteration of hormonal signaling, increased genetic expression of mammary tissue, and resulted in up to 15.0% improvements in milk production. Similar to Lammers et al.(1999), the experimental methodology (Ford and Park, 2001) used to implement energy restriction realimentation protocols was limit feeding. Control heifers were allowed ad libitum access to a diet containing 12.0% CP and 1.07 Mcal/lb of ME, while energy restricted realimentation heifers were limited to 70% of the same diet during energy restriction phases. Limiting feed intake to 70% of the control diet resulted in improving feed efficiency (approximately 30%). The hypothesis and design of these experiments was to investigate energy restriction, which yielded positive lactation responses. The energy restriction, however, was facilitated by limit feeding, not by energy dilution of the diet. Data suggest that there were no negative confounding aspects associated with limit feeding to facilitate limiting dietary energy intake.

There are additional examples in the literature (Hof and Lenaers, 1984; Sejrsen and Foldager, 1992; Van Amburgh et al., 1998; Carson et al., 2000) that employed some form of limit feeding in an experiment to investigate an alternative hypothesis in heifer production and management. While no direct linkage can be made from experimental results to limit feeding per se, the limit feeding methodology employed in these experiments did not result in any negative effects on milk production. In all the experiments outlined above, milk production was numerically greater, regardless of hypothesis studied, for heifers that were limit fed as a part of the methodology.

Limit-Feeding Research – Central Hypothesis

As previously stated, limit feeding is not new and has been employed by researchers as a method to execute experimental designs for other hypotheses. Likewise, it can be assumed that some forms of limit feeding heifers have been employed by dairy producers over time. Recently, it has been consciously recognized that limit feeding methods applied in experiments appear to have a more robust applied utility. Limit feeding has been utilized in experiments as a method to control growth rates, decrease energy intake, decrease feed usage, improve feed efficiency, or improve lactation performance. These are exactly the same goals as the goals of commercial heifer production. As a result, 2 recent experiments have been conducted evaluating limit feeding as a central hypothesis to explore applied applications.

At the University of Wisconsin, we explored a simple limit-feeding system for bred replacement heifers (Hoffman et al., 2007). A summary of trial results is presented in Table 1. Bred Holstein heifers were fed diets (C-100, L-90, and L-80) containing 67.5, 70.0, and 73.9% total digestible nutrients, **(TDN)** respectively, but heifers fed the 70.0 and 73.9% TDN diets were limit-fed at 90 and 80% of their intake potential. The study was designed to provide iso-caloric and iso-nitrogenous intakes. Limit feeding resulted in heifers being fed less DM per day, but the total amount of calories consumed

per day was equal. We did not observe any differences in the size or body condition scores of the heifers after a 111-day feeding period. The limit-feeding regimen, however, resulted in a 25% improvement in feed efficiency, and heifers excreted significantly less manure. We observed no effects of limit feeding heifers on calf BW or dystocia index. As with pseudo limit feeding experiments, we observed a numerical trend in improved milk yield, but true lactation performance was similar between control and limit-fed heifers.

A second study with limit feeding as a central hypothesis was conducted at Pennsylvania State University (Zanton and Heinrichs, 2007). This study was uniquely different than our study at the University of Wisconsin. Our study was conducted on bred heifers (1000 lb) with a short experimental period (111 days). The Penn State study was conducted on heifers weighing 275 lb, and the heifers were limit fed for the entire prepubertal period (245 days) and then feed a common diet post puberty. The level of concentrate in the limit fed diet (75%) was higher than the level of concentrate we fed to bred heifers (37%). A summary of the key results from the Penn State study are presented in Table 2. Limit feeding 300 lb Holstein heifers the diet containing 25% forage as compared to feeding the diet containing 75% forage ad libitum resulted in no differences in ADG or skeletal growth of heifers. Heifers reached puberty at the same age and had similar reproductive performance. Heifers calved at the same age, but limit fed heifers had numerically higher BW at calving and lost more BW after calving (data not shown). As with previous studies limit fed heifers produced numerically higher amounts of milk with similar milk composition.

It is important to recognize the uniqueness of each of these studies. In the Wisconsin study, heifers were limit fed post puberty, while the heifers in the Penn State study were limit fed pre puberty. Both limit feeding strategies resulted in similar animal performance. To date, there are no data for limit-feeding heifers throughout the majority of the rearing period.

Limit Feeding – Changes in Heifer Behavior

There are some changes in heifer behavior as a result of limit feeding. In our study at the University of Wisconsin (Hoffman et al., 2007), we monitored several aspects of heifer behavior (Table 3). First, heifers vocalized to a minor extent for approximately one week at the initiation of the study, with vocalization diminishing thereafter. Vocalization is primarily limited to bellowing immediately prior to feeding. In addition, eating time is logically reduced when heifers are limit fed, but heifers appear to compensate for reduced eating times by standing more, which ultimately reduces lying times. Despite observation of changes in behavior, the behavioral changes we observed when heifers are limit fed appear to be subtle and manageable.

We have observed some undocumented quirks in heifer behavior as a result of limit feeding. In preface to explaining these observations, it should be noted that with most of the experiments defined above, the heifers were individually fed. For example in the experiment recently published by Zanton and Heinrichs (2007), the heifers were individually fed via calan gates. Limit feeding heifers individually does not allow observation of group feeding behavior dynamics, which could be altered by limit feeding. In our study, heifers were fed in pens (6 heifers/pen) because pen was used as the experimental unit. At the time of the experiment, we failed to anticipate changes in bunk (eating) behavior and did not quantify these issues. As a result, changes in bunk behavior noted from this point forward in the paper are empirical, but we feel that they are worthy of mention.

Changes in eating behavior of heifers limited to 80 to 90% of ad libitum intake are subtle, and overly aggressive eating behavior was not observed.

However, heifers while eating, efficiently push feed forward perpendicular to the feed bunk with their muzzle. When fed on a flat feeding surface, a large portion of the diet will be pushed out of reach by the heifers. If heifers have not reached fill or satiety, heifers will aggressively reach in an attempt to acquire feed which they have displaced too far forward. This reaching behavior requires heifers to splay their fore and hind legs to create torque to lean forward. The long term effect of this behavior on foot and leg health is not known. We corrected this behavior by frequently pushing remaining feed up proximal to the fence line. As a result, we would caution that increased feed push ups may be required when limit feeding heifers in a flat manger.

Another undocumented behavioral change we observed is that heifers appear to become acclimated to limit feeding regimens and eating behaviors carry over for a short time after limit feeding is discontinued. After our experimental period, we transitioned the heifers to a common high bulk, high NDF diet. For a short period of time (5 to 7 days), heifers ate this diet as if limit fed. Visual evidence of additional ruminal distention was obvious. These observations suggest heifers have the ability to rapidly increase rumen volume. Quick and rapid extension of rumen volume has been well documented in lactating dairy cows (Dado and Allen, 1995).

Adequate bunk space is required to assure that all heifers have full access to feed because heifers fed to 80% of intake potential will consume all feed available within 2 to 3 hours. Lack of adequate bunk space could result in displacements at the bunk and ultimately result in un-even ADG. We observed small numerical increases in ADG variance when heifers were limit fed, but variance in ADG was not significant when 1000 lb heifers were allowed 24 inches/heifer of bunk space/heifer. The critical lower limit of bunk space per heifer under various limit feeding scenarios is not known. Finally, limit feeding can not be implemented were edible bedding, such as straw, grass, corn stalks, etc., is used as heifers will consume bedding to reach satiety.

Conclusions

To date, the following can be concluded about limit feeding dairy heifers:

1. Limit feeding decreases feed usage, decreases manure excretion, and improves feed efficiency of dairy replacement heifers.

2. There are no research trials indicating that limit feeding has a detrimental effect on heifer or cow health, or future lactation performance.

3. A hypothesis could be constructed that limit feeding may improve milk production, but mechanisms are not known.

4. Limit feeding does result in some minor changes in heifer behavior, and management may need to be modified to account for such behavior.

5. Limit feeding cannot be implemented when bunk space is limited or in housing systems using edible bedding.

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Table 1. Summary of the results from a University of Wisconsin trial, whereby dairy heifers were limit fed (Hoffman et al., 2007).

Item[3]	Treatment[1]			SEM	Effect (P>)[2]		
	C-100	R-90	R-80		Treatment	Linear	C vs. L
Diet (DM basis)							
Forage, %	94.3	80.3	62.7				
Concentrate, %	5.7	19.7	37.3				
NDF, %	47.3	41.8	35.6				
Nutrient intake, lb/day							
DM	21.3	19.9	18.3	0.4	0.01	0.003	0.006
CP	2.42	2.54	2.57	0.03	0.07	0.03	0.03
NDF	10.06	8.29	6.50	0.16	0.0003	0.0001	0.0002
NE_g, Mcal/day	9.4	9.4	9.5	0.2	---	---	---
Body weight							
Initial, lb	1036	1021	1011	21	---	---	---
Final, lb	1220	1234	1217	19	---	---	---
Feed efficiency, lb DM/lb gain	13.2	10.7	11.1	0.9	---	---	0.09
DM Excretion, lb/day	7.7	6.9	5.8	0.6	---	0.10	0.10
Parturition							
Dystocia index[4]	2.2	2.1	1.9	0.3	---	---	---
Calf BW, lb	91.4	93.3	95.1	3.1	---	---	---
Postpartum BW, lb	1238	1245	1275	21	---	---	---
Lactation performance (0 to 150 DIM)							
Milk yield, lb/day	68.8	68.9	72.4	1.7	---	---	---
Milk fat, %	3.89	3.74	3.68	0.09	---	---	---
Milk protein, %	2.87	2.85	2.89	0.03	---	---	---

[1]C-100 = control heifers fed ad libitum, L-90 = limited to 90% of intake, and L-80 = limited to 80% of intake. Treatment means are expressed as least square means on a per heifer basis. SEM = Standard error of mean.
[2]C = Control (C-100) vs. L = Limited (L-90, L-80); Linear = linear effect of level of restriction. Entries without values were not significant (P > 0.10).
[3]DM = Dry matter, NDF = neutral detergent fiber, CP = crude protein, NE_g = net energy for gain, BW = body weight, and DIM = days in milk.
[4]Dystocia index, 1 = no problem, 2 = slight problem, 3 = needed assistance, 4 = considerable force, and 5 = extremely difficult.

Table 2. Summary of the results from a Penn State trial, whereby dairy heifers were limit fed (Zanton and Heinrichs, 2007).[1]

Item[2]	Treatment		SEM
	Control	Limit-fed	
Diet (DM basis)			
Forage, %	75	25	
Concentrate, %	25	75	
Gain			
BW, lb/day	1.82	1.82	0.02
Withers height, inches/day	0.04	0.04	0.0007
Reproduction			
Age @ puberty, days	333	320	6.0
Conception rate, %	83.0	75.0	7.0
Parturition			
Age @ calving, months	23.3	23.5	0.2
Postpartum BW, lb	1179	1232	24.2
Lactation performance (0 to 150 DIM)			
Milk yield, lb/day	69.7	76.3	3.2
Milk fat, %	3.71	3.95	0.11
Milk protein, %	3.12	3.02	0.04

[1]There were no statistical differences between the 2 treatments for any of the variables shown.
[2]BW = Body weight and DIM = days in milk.

Table 3. Behavior of limit fed heifers when group fed (Hoffman et al., 2007).[1]

Item	Treatment[2]			SEM	Effect (P<)[3]	
	C-100	L-90	L-80		Trt	Trt x Week
Eating, % of time	19.3	15.7	10.3	0.6	0.0001	
Standing, % of time	19.6	24.4	32.9	0.7	0.0001	
Lying, % of time	60.9	59.8	56.7	0.5	0.0001	
Vocalization, % of time	0.02	0.04	1.10	0.2	0.0001	0.03
Eating, hours/day	2.3	1.9	1.2	0.1	0.0001	
Standing, hours/day	4.7	5.8	7.9	0.2	0.0001	
Lying, hours/day	14.6	14.4	13.6	0.1	0.0001	

[1]Time associated with involuntary behavior, such as barn cleaning, blood sampling etc., was not recorded; therefore, percent of time and hours of time will not equal 100 and 24, respectively.
[2]C-100 = Control heifers fed ad libitum, L-90 = limited to 90% intake, and L-80 = limited to 80% of intake. Treatment means are expressed on a per heifer basis; SEM = Standard error of mean.
[3]Trt = Treatment effect. Entries without values are not significant (P>0.10).