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Precision Feeding Dairy Heifers: Strategies and Recommendations

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Topics include:

Nutritional aspects of implementing precision feeding
Management aspects of implementing precision feeding
Example diets

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INTRODUCTION

Dairy heifers represent a large expense of resources including feed, buildings, and labor; yet they return no money to the farm until they calve. Overall management of dairy heifers must be handled in a manner that yields the best quality heifer, with a high potential to be productive, and at minimal cost to the farm and the environment.

Feed represents the largest cost associated with heifer production (Gabler et al., 2000), thus controlling feed cost is a major way to control the total costs of raising the heifer. Feed efficiency (lb milk/lb feed) is an important management concept for lactating dairy cows; however, the concept is seldom mentioned for the growing heifer. Feed efficiency for a growing animal is measured as pounds of gain per pound of feed. There are several factors that can greatly impact feed efficiency in the dairy heifer, such as genetics, forage quality (digestibility), growth rate or stage of growth, body condition or gain in body composition, gestation, heat or cold stress (environmental stresses), and exercise level.

Several of the factors affecting feed efficiency are affected by management, such as housing, types of feed, and nutritional system used for the heifers. An important nutritional aspect related to feed efficiency that has been researched in growing ruminants for several years is the concept of precision feeding, which promotes greater efficiency of nutrient utilization and allows nutrient requirements to be met more precisely. Feeding high concentrate, high energy diets as opposed to traditional high forage diets has also been an area of recent study. Each of these concepts can improve the heifer's feed efficiency, and research has shown that they are additive and can be used together in a single heifer feeding scenario without negatively impacting future productivity (Hoffman et al., 2007; Lammers et al., 1999; Zanton and Heinrichs, 2007). The concept of precision-fed, high concentrate feeding has been the subject of several recent research trials and continues to be studied.

The following is an overview of the important concepts that are part of precision feeding systems for dairy heifers, including example rations. This system uses highly digestible feed sources in a controlled feeding environment with an emphasis on feed efficiency, reducing daily ration costs, and minimizing manure output.

NUTRITIONAL ASPECTS OF IMPLEMENTING PRECISION FEEDING OR HIGH CONCENTRATE, PRECISION FEEDING SYSTEMS

Feed a Balanced Diet

Feeding dairy heifers a balanced diet is always important. In the case of precision feeding, no additional free choice forages are fed, and the balanced diet is likely fed in the form of a TMR or mixture of forage and grain, fed once daily. Based on current published research for precision-fed dairy heifers, nutrient specifications as currently understood are as follows:

Protein: balance primarily for crude and soluble protein

- 14 to 15% CP for pre-pubertal heifers based on 2.15% BW DMI/d.
- 13 to 14% CP for post pubertal heifers based on 1.65% BW DMI/d.

- Maintain at least 30 to 35% soluble CP in the rations at all times.
- Rumen undegradable CP levels in excess of 25 to 30% are not required; use only standard feed sources based on price and availability and not feeds specifically designed for high bypass protein.

Heifers require a specific amount of crude protein daily, and for heifers total protein has been shown to be equally as important as the various protein fractions. Research has shown that added rumen undegradable protein (RUP) is of limited value to the heifer beyond what is found in common feedstuffs. In situations where high RUP feedstuffs are more economical than lower RUP feeds, they may be used; however they should not be used for the added RUP. Soluble (SP) and rumen degradable crude protein (RDP) are efficiently utilized by dairy heifers. In studies with SP added as urea, improved nitrogen retention in rations with SP approaching 40% has been observed. It appears that nitrogen utilization in the precision-fed dairy heifer is efficient, allowing for efficient rumen microbial protein production throughout the day despite feed access being limited to a few hours. In various published research trials, maximum protein efficiency has been demonstrated when heifers are fed diets containing 14 to 14.5% CP (Zanton and Heinrichs, 2008).

Energy: The energy requirement of the heifer will be influenced by the size, growth rate, and environment of the heifer. There are two feeding strategies to meet the energy requirements of growing dairy heifers. First, diets can be formulated at variable energy densities and fed ad-libitum to allow the heifer to select her energy consumption. In the second strategy, heifers' diets can be formulated at a fixed (generally higher) energy content and precision-fed to specifically meet the heifers' energy requirement. Regardless of feeding strategy, heifers should be fed energy to allow 1.75 to 2.00 pounds of average daily gain or approximately 130 kcal of metabolizable energy per pound of metabolic body weight ($BW^{0.75}$).

Fiber (NDF or ADF): The current NRC levels for fiber for dairy heifers may not be warranted based on recent precision-feeding experiments. Traditionally, high levels of fiber or low quality forage were fed to dairy heifers to control dietary energy; however precision feeding high concentrate, low fiber diets effectively accomplishes the same goal. The NDF requirements for growing heifers are not well establish and research has yet to find a detrimental lower limit, but some prudence is required. Heifers fed diets as low as 19% NDF have done very well and have not acquired metabolic or lameness problems under routine management; undoubtedly due to the limitations placed on DMI. Diets lower than 19% NDF have not been studied. The NDF values presented below are generally lower than recommended by NRC. These levels are expected to provide an amount in excess of requirements for adequate rumen function, but at a level expected to be approximately 60 to 70% of voluntary DMI due to limitations of gut fill. It is important to note that in all experiments with dairy heifers where low NDF concentrations have been fed, the heifers have been precision-fed. Thus, if low NDF concentrations are fed, the heifers must be fed with controlled intakes.

Vitamins and Minerals: In precision feeding systems balance for current NRC specifications. At present there are no data to suggest vitamin and mineral requirements are altered when heifers are precision-fed higher concentrate diets.

Feed Ingredient Selections

Given the diversity of feed ingredients available for ration formulation, a comprehensive set of recommendations is not available at this time. Feed ingredients for dairy heifers should be selected on cost, availability, and nutrient composition. There are however a few observations in regard to feed ingredients for precision feeding that are pertinent.

Concentrate sources: Much of the dairy heifer precision feeding research conducted to this point has utilized corn and soybean meal as standard concentrate sources to provide energy and protein. These and other ingredients can vary substantially in price, however. There is opportunity to incorporate numerous byproduct ingredients into precision-feeding systems. As the concentrate proportion of the ration increases, there is greater opportunity and flexibility for including these cost-effective ingredients.

Forage sources: The forage component of the ration is an important consideration for precision-fed heifers. Using high levels of corn silage in precision-fed heifer rations is possible; however, it requires careful monitoring of the heifers because a considerable proportion of the corn silage is corn grain. Many of the rations used in precision feeding research have used corn silage as the principal forage, and no detrimental effects have been observed—even when corn silage was used as the only source of forage (Moody et al., 2007). As another alternative, a precision-fed, high forage diet that is high in corn silage may be used to replace a more traditional diet based on lower quality hay and fed for ad libitum intake.

When feeding high levels of grain to heifers, limiting the amount of alfalfa hay may be required because this combination of feeds may promote the development of chronic, frothy bloat in heifers that are predisposed to this condition. Frothy bloat is the only metabolic or ruminal abnormality that has been observed when heifers have been precision fed high concentrate diets. Frothy bloat appears to occur in about 10 to 15% of Holstein heifers when the concentrate level is very high (about 75% of DM).

Straw or other extremely high fiber forages can be incorporated into precision-fed heifer diets, but it is not recommended as greater excretion of fecal matter will result with little additional benefit associated with this forage source to the exclusion of others. With the exception of limiting the inclusion of alfalfa hay, we are not aware of any forage source that should be specifically avoided or included in a precision feeding system.

MANAGEMENT ASPECTS OF IMPLEMENTING PRECISION FEEDING OR HIGH CONCENTRATE, PRECISION FEEDING SYSTEMS

Weigh Heifers Often

There is probably no management tool that impacts more aspects of heifer rearing than monitoring the weight of heifers. Weighing and monitoring heifers frequently is especially critical for precision-feeding systems. Critical times to weigh heifers would include after weaning, before breeding, at breeding, at pregnancy confirmation, and prior to calving. Average daily gains should be calculated and body condition scores should also be monitored. Based on research ADG of Holstein heifers should be 1.75 to 2.00 pounds per day.

Weighing heifers is a relatively simple means to monitor animal performance, and

this practice is a must for precision feeding dairy heifers successfully. Weighing heifers is increasingly important when precision feeding dairy heifers since an inappropriate level of diet restriction can lead to rapid gains and fat heifers or gains lower than desired. Electronic scales can be placed in alleys or some other easy to handle location to make heifer weighing less of a chore. Basically any time a heifer is handled, she should be weighed. With a precision feeding system heifers must be weighed to allow you know what amount of feeding is required, while maintaining the growth rates needed for breeding at a given age or for calving at a given body weight.

Recommendations:

- Weigh heifers at the same time of day (relative to feeding), otherwise alterations in gut fill can impact ADG calculations.
- Weighing heifers once per month is best, but once your system is stable, less frequent weights can work as long as you at least observe body condition.
- It is best to weigh all heifers; however, on some farms it may not be realistic, as heifer numbers may be labor prohibitive. In this case, weighing a representative group of heifers in a pen each time will suffice. It is important to be sure that this group is representative of the entire group and that the same heifers are weighed each time.
- Monitor individual heifer and group gains against benchmark weights, and alter management, specifically feed intake strategies, as needed.
- If you are in need of a generic spreadsheet to monitor heifer weights and average daily gains, one is available at: www.das.psu.edu/dairynutrition/heifers

Group Sizes

In any group-housed heifer facility minimizing variation in size and age of heifers in each group is important, and it remains important in precision feeding system management. Typically, beyond 4 months of age, heifers should be housed with other heifers as close to the same age as possible and always in groups with less than 200 pounds (90 kg) of weight variation within the group. Often this means having groups with 2 to 4 months of age variation at the most. Post breeding, this number can be increased to 300 pounds (136 kg) weight spread between animals within a group.

Feed Bunk Space

In precision feeding systems, heifers will need 14 to 24 inches of feed bunk space per heifer as they progress from 4 months of age to pre-calving or 22 months of age.

Precision-fed heifers will not have access to feed at all times of day, thus all heifers in a pen must have access to the feed bunk. Overly aggressive and timid heifers are very susceptible to over- or under-nutrition when feed bunk space is limited. **Therefore, it is imperative that all heifers are able to eat at one time.**

There are three strategies that can be used when feed bunk space is limited. The first is clearly grouping animals with peers having similar body weight. The second strategy is to have impediments to free motion at the feed bunk, such as headlocks or closely placed divider posts. This will likely be effective to some degree, but not completely. The third is to feed twice daily at close intervals. For example, feed two-thirds of the daily allotment at 7 a.m. and the remaining third at 9 a.m.; in this way the larger animals can eat more freely at the early feeding and the more timid animals at the second feeding.

Avoid Straw & Wood Shavings as Bedding

Precision feeding dairy heifers is based on meeting energy requirements through a producer-imposed restriction—not by gut fill limiting DMI. Since gut fill and ADG potential will not be maximized, heifers will readily consume edible bedding, which will reverse many of the advantages obtained by precision feeding. If heifers are allowed to consume bedding material the intended balance of the precision-fed diet is compromised. Precision-fed heifers require balanced diets to grow at the desired level. A balanced ration under precision feeding requires complete consumption of the diet that is presented to them each day without consumption of free choice supplemental forage or edible bedding of any kind.

Hungry, But Growing

At the initial implementation of the precision feeding protocol, the heifers will likely vocalize immediately prior to feeding, with the frequency and magnitude increasing toward the next feeding. Research experiences are that this behavior will diminish and virtually disappear by between 10 and 14 days after the implementation of the precision feeding strategy. This is due to a moderate reduction in rumen and gut size needed to accommodate a reduced digestive load, which is one of the reasons for the improved efficiency in precision-fed heifers.

The transition to precision feeding requires time and commitment in a manner similar to the time it takes to increase gut capacity after calving. As long as the heifers are growing according to the ADG goals of your operation and receiving a correctly balanced ration, they are adequately fed.

Make Small Changes

Transitioning heifers from a high forage diet to lower forage, precision fed diet requires incremental steps to allow for adequate rumen adaptation. Research at Penn State has focused on precision feeding heifers high concentrate diets in an effort to learn about the advantages and disadvantages of precision feeding systems; however, it is recognized that feeding higher concentrate diets to dairy heifers is a major nutritional and management shift from traditional heifer diets.

An appropriate precision feeding starting point is to limit the intake of a 50% forage, 50% concentrate diet. This type of diet offers some of the advantages of precision feeding a high concentrate diet and will increase feed efficiency as compared to a traditional high NDF, low-energy diet. The aforementioned diet also does not have as high a potential for producing rumen problems as higher concentrate diets (this is logical because most milking cows are fed this type of diet at substantially greater quantities per pound of body weight).

Transition to Pre-freshening and Post-freshening Diets

Precision feeding should be discontinued and heifers adapted to normal pre-freshening diets 30 to 45 days before calving. Precision feeding heifers until 30 to 45 days before calving has had no adverse effects on calf birth weight, dystocia, metabolic problems, early lactation intakes, or first lactation milk production, as has been reported in several peer-reviewed journal publications. Changes in rumen and gut volume have been shown to occur rapidly and do not limit postpartum dry matter intake.

EXAMPLE DIETS

Listed below are some of the nutrient recommendations that have been determined under experimental and practical situations. It should be noted that the high forage rations as well as the high concentrate rations used in the examples below were precision-fed to produce a level of growth to meet ADG objectives. Precision feeding highly digestible, high concentrate diets is still under development for dairy heifers, and knowledge is still incomplete. But this information can serve as a starting point for those interested in precision feeding dairy heifers. **The final determination for the success of a precision feeding program is the animal herself, and careful and frequent monitoring of heifer progress is the key to successful application of this nutritional approach.**

A strategy for practical ration balancing is to formulate a least cost diet based on the feeds available, meeting the required specifications, and then feed an amount of dry matter to meet the nutrient requirements. That is, assuming energy is most limiting for growth, determine the ME required by a heifer for a specific rate of gain (from the NRC, for instance) and divide the requirement by the formulated ration energy density (Mcal/d ÷ Mcal/pound DMI).

Table 1. Nutrient recommendations for precision-feeding dairy heifers. Values are for Holstein heifers growing 1.9 pounds per day. These are starting values based on precision feeding experiments; actual performance should be monitored and dietary alterations should be made accordingly.

Age, mo	Body Weight, pounds	DMI, pounds/d	ME, Mcal/d	CP, pounds/d	NDF, %
4	250	5.72	7.8	0.9	23
6	350	7.45	10.1	1.1	24
7	450	9.07	12.2	1.4	26
9	550	10.62	14.1	1.6	27
11	650	12.11	16.0	1.8	28
13	750	13.55	17.9	2.0	29
14	850	14.95	19.6	2.2	30
16	950	16.32	21.3	2.4	30
18	1050	17.65	23.0	2.6	31
20	1150	18.96	24.6	2.8	32
21	1250	20.24	26.2	2.9	32
23	1350	21.51	27.7	3.1	33

Table 2. Example rations formulated for lower and higher forage levels and two age groups for ADG of 1.8 pounds/day.

Ingredient, % of DM	Lower Forage		Higher Forage	
	4 Months	23 Months	4 Months	23 Months
Grass Hay	8	15	20	25
Corn Silage	12	25	30	35
Whole Shelled Corn	40.75	31.25	18.70	18.25
Soybean Meal	9	0	8	3
Distiller's Grains	7	15	10	10
Wheat Middlings	10	10	5	5
Molasses	10	0	5	0
Urea	0.50	0.75	0.30	0.75
Mineral Mixture	3	3	3	3
Item				
Body weight, pounds	250	1350	250	1350
DMI, pounds/d	5.56	21.00	5.98	22.08
DMI, %BW	2.23	1.56	2.39	1.63
ME, Mcal/pound DM	1.25	1.17	1.16	1.12
CP, %	16.05	14.62	15.04	14.09
SP, %CP	29.22	38.43	30.26	40.26
RUP, %CP	32.44	36.16	33.31	32.00
NDF, %	22.43	33.87	34.93	39.97

Table 3. Rations used in published research (example 1).

Ingredient, % of DM	High Concentrate	High Forage
Grass Haylage	12.71	38.65
Corn Silage	12.06	36.40
Cracked Corn	47.72	9.27
Soybean Meal	8.71	7.05
Cotton Seed Hulls	12.40	5.09
Urea	1.10	0.17
Bicarbonate	0.88	0.85
Mineral Mix	4.43	2.50
Composition		
ME, Mcal/pound DM	1.13	1.06
CP, %	14.98	11.72
NDF, %	29.78	45.40

Heifers were between 300 and 800 pounds and growing at 1.82 lb/d. **Reference:** Zanton and Heinrichs, 2007.

Table 4. Rations used in published research (example 2).

Ingredient, % of DM	High Corn Silage	Low Corn Silage
Corn silage	76.92	32.98
Ground corn	0.00	27.98
Soybean hulls	7.21	25.00
Sodium bicarbonate	0.67	0.67
Canola meal	5.67	9.62
Expeller soybean meal	7.12	0.00
Mineral mix	2.40	3.75
Composition		
ME, Mcal/pound DM	1.12	1.12
CP, %	10.3	12.25
NDF, %	41.7	38.3

Heifers were between 380 and 750 pounds and growing at 1.8 lb/d. **Reference:** Moody et al., 2007.

Table 5. Rations used in published research (example 3).

	10 Months	22 Months	10 Months	22 Months
Ingredient, % of DM	**Concentrate**		**Forage**	
Grass Hay	12.82	12.82	3.04	3.04
Alfalfa Hay	1.97	1.97	34.99	34.99
Corn Silage	9.41	9.41	36.23	36.23
Ground Corn	56.96	56.96	14.73	14.73
Soybean Meal	6.96	6.96	3.93	3.93
Cottonseed Hulls	4.91	4.91	2.02	2.02
Corn Distillers Grains	2.30	2.30	2.59	2.59
Urea	0.93	0.93	0.05	0.05
Mineral Mix	3.74	3.74	2.42	2.42
Item				
Body weight, pounds	572	1274	585	1289
DMI, pounds/d	10.6	20.0	11.4	21.3
DMI, %BW	1.85	1.57	1.95	1.65
ME, Mcal/pound	1.21	1.20	1.12	1.11
CP, %	15.31	15.31	14.15	14.15
NDF, %DM	27.86	27.86	39.61	39.61
Forage NDF, %NDF	50.6	50.6	83.9	83.9

Reference: Zanton and Heinrichs, 2006.

CONCLUSIONS

In summary, studies have shown that feeding higher concentrate rations in a restricted manner to growing dairy heifers from 4 to 22 months of age leads to similar growth performance with respect to weight gains and structural growth. Research results suggest, provided the level of intake is restricted to allow for an optimal level of ADG, high concentrate, precision-fed rations can be fed to dairy heifers successfully. Precision feeding heifers has the potential to reduce feed costs, reduce nutrient excretion, and increase feed efficiency without compromising future lactation performance.

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