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Feed and Animal Management for Dairy Cattle

Acknowledgments

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Introduction

Dairy operations typically include the milking cow herd with some of the cow population in the non-lactation stage (dry cows). The milking cow herd may even be split further by stage of lactation, or by high, medium, and low producers. Operations may or may not include growing heifers being raised as replacements for the milking herd. Distinctly different diets are required for each of these groups and different stages of the production cycle resulting in great differences in the volumes and nutrient compositions of manure. This technical note briefly highlights some factors affecting nutrients in manure from dairy cattle and modifications in the diet that can be used to reduce them.

A critical part of feed management is to accurately formulate diets and manage the feeding of them so that the nutrients fed consistently match the nutrients needed by each group in the herd. For example, table 1 shows how the concentration of nutrients needed in the diet change with stage of the life cycle and level of milk production. This table is only an example to illustrate how the diet formula needs to be specific for each group in the herd. The concentration of nutrients needed in the diet for a particular level of production changes with dry matter (DM) intake.

Table 1: Selected Nutrient Requirements of Dairy Cattle (as determined by sample diets)[1]

Holstein, 1,500 lb cow, average body condition, 65 months of age	**Stage of Production**						**Dry, pregnant, 270 days in gestation body weight = 1,656 lb**	**660 pound heifer, @1.91 lb gain/day**
	Early lactation		**(90 days in milk)**					
Milk Yield, lb/day =	55	77	55	77	99	120	n/a	n/a
DM intake, lb/day	29.7	34.3	44.7	51.9	59.2	66	30.1	15.6
Net energy, Mcal/lb	0.94	1.01	0.62	0.67	0.7	0.73	0.48	1.03
Diet, % RDP	10.5	10.5	9.5	9.7	9.8	9.8	8.7	9.4
Diet, % RUP	7	9	4.6	5.5	6.2	6.9	2.1	2.9
Crude protein[2], %	17.5	19.5	14.1	15.2	16	16.7	10.8	12.3
NDF[3], min %	25-33	25-33	25-33	25-33	25-33	25-33	33	30-33
NFC[4], max %	36–44	36–44	36–44	36–44	36–44	36–44	42	34–38
Calcium, %	0.74	0.79	0.62	0.61	0.67	0.6	0.45	0.41
Phosphorus, %	0.38	0.42	0.32	0.35	0.36	0.38	0.23	0.23
Potassium[5], %	1.19	1.24	1	1.04	1.06	1.07	0.52	0.48
Sodium, %	0.34	0.34	0.22	0.23	0.22	0.22	0.1	0.08
Copper[6], mg/kg	16	16	11	11	11	11	13	10
Zinc, mg/kg	65	73	43	48	55	65	22	27

1/ Adapted from Tables 14-7, 14-8, 14-9, and 14-16 of National Research Council. 2001. *Nutrient Requirements of Dairy Cattle: Seventh Revised Edition, 2001*. Washington, DC: The National Academies Press. https://doi.org/10.17226/9825.
2/ Equivalent to the sum of rumen degradable protein (RDP) and rumen undegradable protein (RUP) only when they are perfectly balanced.
3/ Neutral detergent fiber (NDF) is the most common measure of fiber used for animal feed analysis and measures most of the structural components in plant cells. The level of NDF in the animal ration influences the animal's intake of dry matter and the time of ruminations. The concentration of NDF in feeds is negatively correlated with energy concentration.
4/ Non-fibrous carbohydrates (NFC) (sugars, starches, organic acids, and pectin) are broken down by the animal for energy production.
5/ Heat stress may increase the need for potassium.
6/ High dietary molybdenum, sulfur, and iron can interfere with copper absorption, increasing the requirement.

Diet Formulation

Diets should be formulated and updated regularly to avoid overfeeding of nutrients or fluctuations in milk production. The most common guideline for diet formulation is the National Research Council (NRC) publication "Nutrient Requirements of Dairy Cattle." This publication provides equations to compute nutrient requirements for any size cow and milk production level and stage of the life cycle. Therefore, actual DM intakes and a computer program containing NRC and/or other research-based equations should be used to formulate diets. Because of the complexity of formulating diets to optimize production while minimizing excretion, producers not trained in nutrition should obtain help from qualified nutritionists when formulating diets. Proper diet formulation requires routine (monthly or quarterly) forage and by-product analysis due to the high variability of these ingredients. Tabular values and previous sample analyses are not reliable for determining the nutrient content of these feed ingredients because of this variability. Specific tests can aid in the overall achievement of nutrient reductions; these might include tests for neutral detergent fiber digestibility (NDFd), starch, and starch digestibility, among others. Conducting a routine moisture analysis is important to adjust and mix feeds to ensure delivery of the formulated diet to the cattle. Cows should be evaluated for their body condition routinely so that the proper energy level of the diet can be determined.

Depending upon the stage of production, the forage to concentrate ratio can vary tremendously. A 50 percent variation in manure production might result from differences in feed wastage, ration formulation, type of feeding and/or animal grouping systems. Since dairy cattle are ruminants, they can utilize forages (generally lower in digestibility) as well as concentrates (generally higher in digestibility) in their diets. As a result, volumes of manure produced are much greater when poorly digestible forages (fiber) are fed as compared to highly digestible forages and concentrates. In addition, the availability of nutrients in forages can vary considerably with different forage species and stage of maturity. Also, the composition of the manure is significantly different with these different scenarios.

Studies have shown that selecting the right type of protein sources in the diet to meet animal requirements can reduce nitrogen (N) excretion by 15–25 percent. Most of the N consumed by cattle is a part of the protein in the diet. When cows consume excess protein, an increased amount of N is excreted in the urine as urea. Small amounts of urea can also be diffused into the milk. The concentration of urea in milk is proportional to the amount of N excreted in urine for cows with a given body weight. Cows consuming excess protein typically will have higher milk urea nitrogen (MUN) concentration than cows consuming protein at or below their requirements. MUN can be measured for use as an indicator of excess protein in the diet. A general rule is that an average herd MUN should fall between 8 to 12 mg/deciliter (dl) of milk. (See link from the Livestock and Poultry Environmental Learning Center for more information on the relationship between rumen digestible protein (RDP) and MUN at: https://lpelc.org/interpreting-milk-urea-nitrogen-mun-values/).

The recommendation from the NRC (2001) for phosphorus (P) feeding is a range of about 0.32 to 0.42 percent of diet DM content, depending upon level of milk production and stage of lactation. Yet many producers are feeding closer to 0.5 percent for all lactating cows. Farmers often overfeed P with the thought that they will: (1) improve reproductive efficiency, (2) maintain the correct calcium to phosphorus ratio to help avoid milk fever, and (3) that the feed ingredient tables typically underestimate the amount of P in most ingredients.

Mineral P supplements such as dicalcium phosphate or monocalcium phosphate have been added to dairy cow diets at levels exceeding recommendations to provide a "safety margin," especially if reproductive problems are suspected. As a result, diets typically contain 25 to 35 percent more P than recommended by the NRC. By reducing or removing all supplemental P in the dairy diet, P excretion can be reduced in manure by as much as 30 percent.

Overfeeding P for reproductive performance has no scientific basis. Research shows that using accurate requirements for P along with actual feed analysis to formulate diets will optimize animal performance and minimize P concentration in manure. Forages, in particular, are highly variable in P content and should be determined for each farm using wet-chemistry procedures.

By-products (e.g., products of the brewing and distilling industries) are often utilized in cattle diets. Balancing the proper nutrient levels in cattle diets can be challenging when by-products are used. A consideration of using by-products is that the concentration and availability of nutrients, especially N and P, from each feed ingredient source can vary greatly, causing significant variation in nutrient contents that can create excesses in the diet. As carbohydrate (sugar and starch) in the grain is turned into alcohol and removed, the proportion of protein, fat, and minerals in the residual increases. Distillers and brewers' grains can be high in P and N because of this. Adequate testing of these by-products should be done to determine nutrient levels to obtain the correct feed balance.

The dietary salt intake level should be reduced in cattle feeds in semiarid and arid climates where salinity problems can exist and sodium accumulation can adversely affect crop production. In addition, beware of potassium accumulation in forages receiving high levels of manure application. This can potentially cause grass tetany problems in cattle consuming such forages, and can cause milk fever in fresh cows.

Production Management

Several technologies have the potential to reduce manure nutrients per 100 lb. of milk produced. One such technology is the manipulation of photoperiod by the provision of artificial lighting. It has been shown that increasing day length can increase milk production in dairy cattle, increase nutrient intake required by such light-stimulated herds, accompanied by N and P excretion rates at a lower level than the increased intake, when compared with similar herds under natural day length.

Penning and grouping dairy cattle of similar milk production levels or stage of lactation and formulating diets to more nearly meet the nutritional needs of cattle will reduce feed nutrient wastage. Uniform groups (by weight and stage of production) allow the producer to utilize diets that more closely match the actual needs of all animals in the group, since there is less variation between animals and overfeeding of nutrients can be minimized.

Dividing the milk production cycle into several periods with less variation in milk production within the group allows producers to provide diets that more closely meet the cattle's nutrient requirements. Use of phase feeding has been estimated to reduce N and P excretion in the manure by at least 5 to 10 percent.

Milking three or more times instead of twice per day can increase production per cow and reduce stress on a herd. The increase in production per cow results in the consumption of a given percentage more protein, with a decreased percentage more nutrients excreted in manure. The extra milking(s) per day reduces the amount of nutrient excreted in the manure per unit of milk.

Feed Management

Feed Mixing

In many instances, the formulated ration is not being followed, exactly, due to different amounts of feeds being added to a mix than what was prescribed by the dairy nutritionist. In many cases, adding feed ingredients to the mix based on "buckets full" rather than by a precise measurement will cause variability in the ration. A better practice is to incorporate a feed weighing system on both the mixing and the feed delivery systems to ensure that the animals are receiving the required nutrients. It may be difficult to mix a ration correctly on farm because the ingredients may vary in quality and nutrient content. It is important to test ingredients often to verify that the animals are actually receiving what the nutritionist has prescribed. Forages should be tested for DM percentage on a regular basis because changes in DM can affect the concentration of nutrients in the total ration. A number of practices should be included in a feed mixing system to ensure that the animals receive the amounts of nutrients prescribed. These feeding practices might include total mixed ration (TMR) audits to monitor the feed which was fed, following load orders to make sure that the correct amounts of ingredients have been used, and monitoring mixing times and mixer rpm to document that there are no "hot spots" in the feed that are heavy in one nutrient or deficient in another.

Feed Bunk Management

Good bunk management is imperative to reduce feed wastage. This involves checking feed intake levels for each group in the herd and adjusting intake to that required for the production level of each group. Consideration should also be given to how much feed is being wasted. In some operations, leftovers are collected from lactating cows and re-fed to nonlactating cattle. In other cases, refused feed is scraped from the feeding area and discarded. In this situation, waste removed from the lot will include wasted feed and manure nutrients that need to be applied to the land.

A herd of 500 lactating cows will eat around 30 lb. of forage per day (60% DM) per cow. If there is 3 percent feed wastage, this translates to over 80 tons for the herd per year that can be valued at eight to ten thousand dollars. Not only is this waste feed important to the economic viability of the operation, but the nutrients in the waste must be dealt with in the environment.

Feed Storage

Proper feed storage is necessary to preserve the nutrient value of the feed and to reduce direct loss of nutrients to the environment. Nutrients in water can come from leachate from fermented feeds (such as silage) and from runoff from feeds exposed to rain. Containment of silage leachate and good management of all feed storage areas is advised so that feed-based nutrients will not be lost directly to the environment. Wrapping hay bales or storing hay or other feedstock under cover will minimize losses to the environment.

Nutritional Value of Water

A lactating dairy cow requires on average between 15 and 35 gallons of water per day; nonlactating dairy and beef cows require about 15 gallons per day. A quick rule of thumb is that for every 2 lb. of dry feed intake, an animal should receive one gallon of water. This will vary with stress, weather conditions, heat, cold, disease, productive state, work, exercise, etc., as well as the water and salt content of the feed.

The mineral content of the water supply should be considered with regard to the total intake of dietary minerals. Depending on the quality of the water supply available, water intake may make a substantial contribution to daily mineral intake, particularly with regard to sulfur, and in some areas of the country, salt. Routine water sampling can help the nutritionist formulate properly for the amount of minerals that need to be added to the diet to meet the animal's actual requirements.

Pasture-Based Management

Modern pasture management has evolved to optimize use of forage resources in pasture systems. Such systems require intensive management of pasture for optimal DM and nutrient yields and for optimal feeding and nutrition of high producing modern dairy cows. To achieve these objectives, pastures must be rotated frequently so forages are consumed at an optimal stage of growth and overgrazing does not occur. Pastures are typically divided into paddocks via the use of easily moved electric fences. Cattle are rotated through paddocks as forages reach stages of growth optimal for both DM yields and nutrient composition.

From a nutritional standpoint, the three major challenges of pasture-based dairy systems are maintaining favorable rumen fermentation conditions, maintaining adequate DM intake, and meeting energy and protein requirements. Managing rumen health and dietary fiber adequacy can be as challenging with pasture-based systems as with other dairy feeding systems. Lush, rapidly growing pasture grasses with high energy and protein density typically have low neutral detergent fiber concentrations. High protein density can also result in high levels of MUN in pasture-based diets. Rumen fermentation conditions, particularly pH, may be a problem. Supplementing the pasture with dry forages to maintain adequate effective fiber concentrations is frequently necessary. Allowing pastures to mature to some extent into taller forages, before they are grazed may help with protein density, NDF and MUN levels, and with ammonia excretions.

Dry matter consumption in pasture systems may limit nutrient intake because maximal consumption rates are lower than in confinement systems. This will limit energy intake, thus requiring supplemental energy sources to be fed to achieve high milk production. Milk production rates in unsupplemented pasture feeding situations are seldom >55 lb/day. Energy supplements may include starches such as cereal grains or highly fermentable fiber sources such as grain by-products. Protein, and particularly sources of rumen undegradable protein, may also need to be supplemented. Protein concentrations in pasture grasses may be high but are generally highly rumen degradable.

Summary

The NRC publication "Nutrient Requirements for Dairy Cattle" is a key reference to evaluate dairy cattle diets on a commercial operation. Also, consult qualified nutritionists to accurately evaluate current or planned diet compositions during the development of a conservation plan, particularly during the development of a comprehensive nutrient management plan (CNMP). A variety of feed management activities can impact the nutrient content of excreted dairy cattle manure. Table 2 lists the "potential" of various feed management strategies to decrease the N and/or P content of manure excreted by dairy animals.

Table 2: Potential for Feed Management to Impact the Nutrient Content of Dairy Cattle Manure

Strategy	Nitrogen Reduction %	Phosphorus Reduction %
Minimize dietary nutrient excesses	10–15	10–30
Protein manipulation	15–25	n/a [a]
Increase the number of production groups	5–10	5–10

[a/] Not applicable

The actual impact of a feed management strategy or strategies on a dairy operation can only be determined by analysis of a good representative sample of the manure (taken from several animals or several locations in the storage area) after the strategy has been implemented. During the development of CNMPs, the potential impact of such strategies can be estimated using values in table 2. In using data from this table, planners are encouraged to be conservative in their selection of factors. Also, it is important to remember that the impact of using multiple strategies in a single diet is not likely to be additive for each single strategy being used. Rather, it is more likely to be something greater than the value for the strategy with the smallest impact, but less than the sum of the values for all the individual strategies being used.

It is better to underestimate the potential impact of feed management than to overestimate it, especially for the development of CNMPs. Later, the plan can be modified and "fine-tuned" based upon data accumulated from the actual production operation.

References

Merck Sharp & Dohme Corporation, a subsidiary of Merck & Company, Inc. 2016. MSD Veterinary Manual, 11th Edition. Kenilworth, NJ.

National Research Council. 2001. Nutrient Requirements of Dairy Cattle: Seventh Revised Edition, 2001. Washington, DC: The National Academies Press. https://doi.org/10.17226/9825.

Appendix 1

Glossary of Terms

By-products.—Feed ingredient sources that are normally waste products of other industries.

Concentrate.—Plant material that contains a high starch content.

Diet Formulation.—The process of combining an assortment of feed ingredients into a diet that will meet the nutrient and energy requirements for the intended purpose of the animal production system.

Forage.—Plant material that contains a relatively high fiber content.

Phase Feeding.—Changing the nutrient concentrations in a series of diets formulated to meet an animal's nutrient requirements more precisely at a particular stage of growth or production.