Considerations and Resources

on Feed and Animal Management

Cow of the Future™ Report to Improve Business Value and Reduce Greenhouse Gas Emissions

INNOVATION CENTER FOR U.S. DAIRY®
HEALTHY PEOPLE • HEALTHY PRODUCTS • HEALTHY PLANET

About the Resource

Produced in the gastrointestinal tract of the cow during digestion, enteric methane emissions are the single largest source of greenhouse gas emissions in the fluid milk value chain. Feed and animal management provide great potential to not only reduce these emissions, but to increase milk yields, improve nutrient use efficiency and, in some cases, improve the nutritional qualities of milk.

"Every dairy farm across the U.S. is different, but I believe all of them have a common goal: to take steps — some small and some large — toward becoming more efficient and profitable contributors to our nation's food system and to our communities."

Steve Maddox, Maddox Dairy,
Riverdale, California,
Sustainability Council Member,
Innovation Center for U.S. Dairy®

Considerations and Resources on Feed and Animal Management was developed by Cow of the Future™ for the Innovation Center for U.S. Dairy® with the support of the David and Lucile Packard Foundation and academic and industry contributors across the U.S. and international dairy industry. It is intended to provide guidance to dairy farmers and other professionals who contribute to on-farm decisions on feed and animal management.

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September 2014

Preface

As the world population continues to grow, agriculture must focus on production efficiencies to provide an adequate food supply. The challenge is to reduce greenhouse gas (GHG) emissions while meeting the growing global market demand for milk and dairy foods.

In January 2009, the Innovation Center for U.S. Dairy® — which includes 31 chief executive officers and chairmen in the dairy industry — committed to reducing industry-wide GHG emissions by 25 percent by 2020. Cow of the Future™ was established to address enteric methane produced by dairy cows during the process of feed digestion. This is the single largest source of GHG emissions in the dairy supply chain.[1]

The good news for farmers is that reducing enteric methane provides both environmental and financial value. Technologies and management practices that improve livestock productivity also provide the most cost effective means, available today, to reduce methane emissions per unit of energy corrected milk.

Cow of the Future's first focus was to catalogue and disseminate existing mitigation practices for adoption by U.S. dairy farmers, large and small. *Considerations and Resources on Feed and Animal Management* is a major accomplishment towards supporting industry-wide goals.

Considerations and Resources on Feed and Animal Management is intended for use by those who make on-farm decisions — dairy farmers, nutritionists, veterinarians and others. Because every dairy farm is different, the report is not prescriptive; rather, it incorporates considerations and resources. The "considerations" provide users with guidance in finding feed and animal practices that are best-suited for their individual operations. The "resources" provide relevant and in-depth information on the actual practices and their underlying fundamental principles.

The document includes:

- 215 considerations on ration formulation, feeding, forage and concentrate management, and cow and calf care presented in 34 easy-to-use tables, and
- 257 supporting resources, that were selected from a comprehensive list of journal articles, conference proceedings, practice standards, books, extension publications, and websites all of which are accessible online by clicking on the hyperlinks provided

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[1]Thoma G, Popp J, Nutter D, et al. Greenhouse gas emissions from milk production and consumption in the United States: a cradle-to-grave life cycle assessment circa 2008. International Dairy Journal 2013;31(1):S3-S14. http://dx.doi.org/10.1016/j.idairyj.2012.08.013

Preface

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This report represents an unprecedented effort to consolidate and synthesize practical information that is:

1. supported by existing science
2. can be immediately used by dairy farmers to add environmental value by reducing enteric emissions and increase on-farm financial value.

It, also, reflects the collaborative effort of more than 40 dairy professionals in industry and academia. Developing *Considerations and Resources on Feed and Animal Management* would not have been possible without the effort and generosity of those who contributed time and expertise at their own expense (see Acknowledgments). We are extremely grateful to all of them.

Our sincerest hope is that this document becomes a valued reference for all dairy farmers — as they continue on their improvement path to more effectively deliver responsibly-produced, nutritious dairy products that support the health of people, planet and community. For more information about Cow of the Future, visit www.USDairy.com/cowofthefuture.

Juan M. Tricarico, PhD
Director, Cow of the Future™
Editor, *Considerations and Resources of Feed and Animal Management*

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Chapter 1: Ration Formulation and Feeding

Chapter Content

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1.2 Energy Requirements
1.3 Protein and Amino Acids Requirements
1.4 Ingredient and Diet Nutritional Analysis
1.5 Dry Matter Intake and Feed Efficiency
1.6 Feeding Management
1.7 Drinking Water

Introduction

Good feeding practices and a balanced diet that meets animal requirements for high levels of productivity, (i.e., growth and milk yield) health and reproduction, will improve profits and reduce enteric methane emissions per unit of fat- and protein-corrected milk. Ration formulation is truly a balancing act requiring a careful combination of various feedstuffs to ensure that nutrients are not over- or underfed to each animal class in a dairy herd. Routinely using available mathematical models to optimize rations for each animal class in the herd is highly encouraged.

Ration formulation has a significant impact on profitability and enteric emissions because it directly affects feed intake, fermentable energy availability, passage rate, feed efficiency and other factors that influence ruminal digestion, enteric methane formation and nutrient supply in dairy cattle. The implementation of ration formulation practices requires consideration of rumen function, animal requirements, the net energy system and energy partitioning, metabolizable protein and concepts of feed efficiency, dilution of maintenance, and ingredient and diet nutritional analyses (i.e., composition and digestibility).

1.1 Rumen Function

The function of the rumen is to allow pre-gastric fermentation of feed by ruminal microbes capable of digesting fiber (i.e., plant structural carbohydrates) in the absence of oxygen. As such, rumen function is vital to the survival and productivity of dairy cattle.

Healthy rumen function allows mixing of digesta, promoting turnover and accessibility of coarse fiber particles for rumination and microbial digestion.

Dairy nutritionists must ensure adequate nutrient supply for maximum fat- and protein-corrected milk production while maintaining rumen function in the dairy cow. A healthy rumen will support extensive feed digestion and microbial protein synthesis, stimulating milk production.

Because of its amino acid profile, microbial protein is efficiently converted by the cow into milk protein. High levels of microbial protein production are desirable and are influenced by ruminal conditions, such as pH and carbohydrate and nitrogen availability to the rumen microbes.

When rumen function is impaired, feed digestion, intake and productivity drop, and the health of the animal may be compromised. Feeding unbalanced rations may also lead to ruminal disorders such as bloat and subclinical acute acidosis (SARA). Feeding excessive starch and inadequate long fiber is an example of an imbalance in the diet that leads to SARA and limits milk production. These imbalances must be avoided to improve productivity and reduce enteric methane emissions per unit of fat- and protein-corrected milk.

1.1 Rumen Function

Considerations

- Supply combinations of energy and protein sources that maximize microbial protein synthesis
- Supply adequate energy without excessive amounts of rapidly fermentable carbohydrates that reduce rumen pH
- Monitor indicators of rumen health (rumination activity, manure appearance, milk fat percentage and hoof health)
- Assess ration particle size (Penn State Particle Size Separator, visual inspection) and adjust dietary fiber supply accordingly (see 1.4 Ingredient and Diet Nutritional Analysis, 2.1 Forage Importance and Contributions and 2.4 Forage Harvest and Processin)
- Consider the inclusion of dietary feed additives that enhance rumen function (see 3.5 Feed Additives)

Resources

- **Carbohydrate Nutrition and Manure Scoring, Part II: Tools for Monitoring Rumen Function in Dairy Cattle** (2007) Hall, M. B. http://conservancy.umn.edu/bitstream/109852/1/Hall 2.pdf
- **Dairy Cattle Nutrition of Milking and Dry Dairy Cows** Extension http://www.extension.org/pages/15603/dairy-cattle-nutrition-of-milking-and-dry-dairy-cows
- **Dairy Cattle Nutrition Publications.** UW-Extension http://www.uwex.edu/ces/dairynutrition/pubs.cfm

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1.1 Rumen Function

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Resources

- **Feed Management: Conservation Practice Standard 592** (2003) NRCS http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/?cid=nrcs143_026849
- **Feeding the Dairy Herd** (2005) Linn, J. G. et al. http://www.extension.umn.edu/agriculture/dairy/feed-and-nutrition/feeding-the-dairy-herd/
- **New Developments in TMR Particle Size Measurement** (2011) Kononoff, P. J. et al. http://www.extension.org/pages/26270/new-developments-in-tmr-particle-size-measurement
- **Subacute Ruminal Acidosis in Dairy Cattle** (2003) Oetzel, G. R. http://www.wcds.ca/proc/2003/Manuscripts/Chapter%2024%20Oetzel%20.pdf

1.2 Energy Requirements

Dairy animals obtain energy from feed through the processes of digestion and metabolism. This energy is used to support maintenance, physical activity, growth, pregnancy and milk production. Energy in dairy feed is primarily supplied by carbohydrates with fat and protein providing smaller amounts.

Nutritionists describe the flow of energy through the animal, or energy partitioning, using a basic model known as the net energy for lactation (NEL) system. This system describes energy supply and energy losses associated with digestion and metabolism, and energy availability for productive purposes **(see Figure 1)**.

It is in everyone's best interest to decrease energy losses in feces, enteric methane, urine and heat production. The NEL supplied by

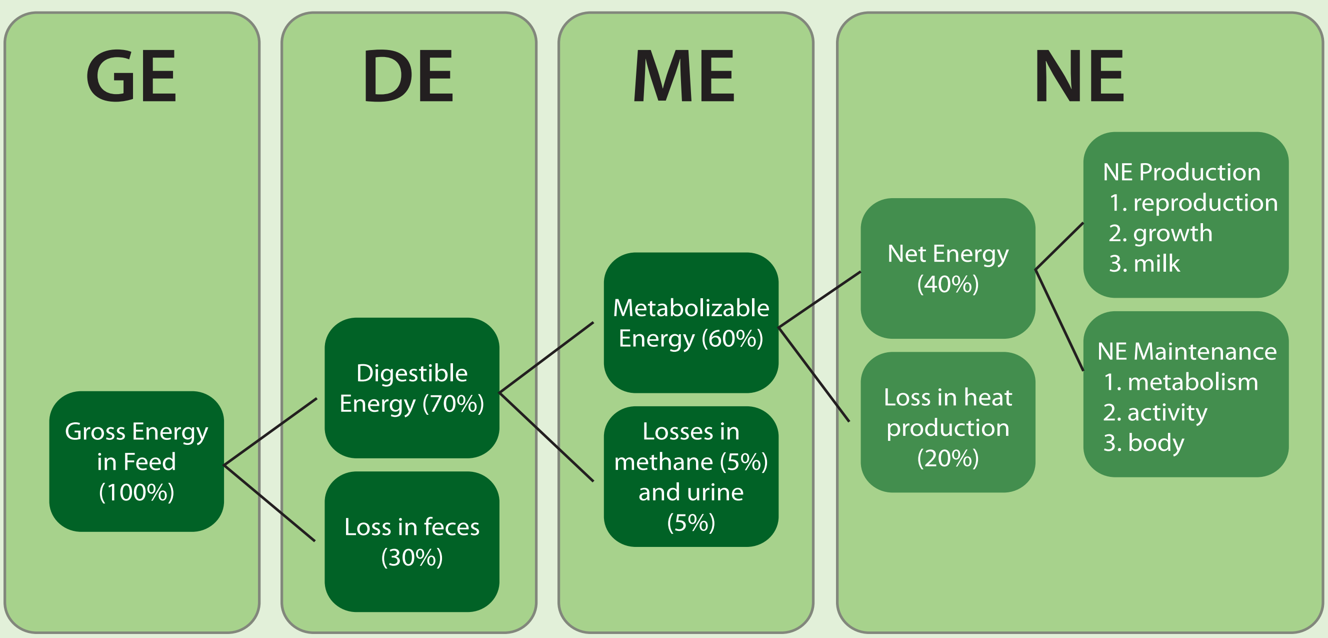


Figure 1: Illustrative example of the partitioning of ration energy (60% alfalfa and 40% corn) and the associated losses in a lactating cow (see above, Feeding the Dairy Herd, Linn et al., 2005)

feeds is estimated based on their contents of non-fiber carbohydrate (NFC, which is mostly starch), crude protein (CP), fat and neutral detergent fiber (NDF). Energy supply adjustments are made according to predicted digestibility and rate of passage of feeds.

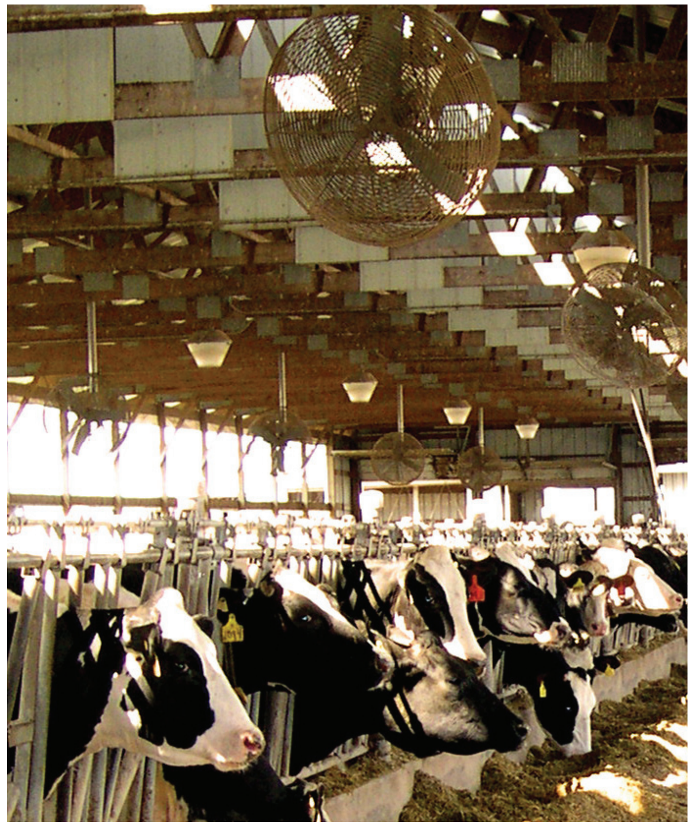
The total amount of energy in feed delivered to a cow is called gross energy (GE), but the cow cannot digest all that energy and loses some in feces. The remaining GE digested by the animal is referred to as digestible energy (DE). Digestion and metabolism include a variety of biochemical processes during which:

1. ruminal microbes digest feed and turn it into energy-rich substrates in the form of volatile fatty acids (VFA) that the cow absorbs from the rumen, and
2. the cow itself digests a portion of undigested feed that escapes microbial fermentation in the rumen, providing energy-rich compounds that are absorbed at the intestinal level.

During digestion and metabolism, energy is lost in the forms of gas and urine. The gas is lost largely as carbon dioxide, methane and occasionally some hydrogen. The amount of energy remaining after subtracting gas and urinary losses from DE is called metabolizable energy (ME).

Finally, the energy loss due to heat production resulting from digestion and metabolism is subtracted from ME to provide the net energy (NE) available to the animal for productive purposes.

All cows are not created equal. Natural variability between cows means that high-yielding cows have the ability to partition more energy into milk. These cows will also produce less methane per unit of milk produced.



1.2 Energy Requirements

Considerations

- Meet net energy requirements (NRC, 2001) of each dairy cattle group on the farm
- Dilute maintenance energy requirements by maximizing milk production
- Focus on improving forage fiber digestibility to promote forage intake and rumen health and maximize productivity
- Reduce fecal losses by maintaining rumen health, processing feed and maintaining an effective rumen mat to slow rate of passage of grains

1.2 Energy Requirements

Resources

- **Energy** (2001) National Research Council: Nutrient Requirements of Dairy Cattle: Seventh Revised Edition (pp. 13–27) http://www.nap.edu/openbook.php?record_id=9825
- **Energetics for the Practicing Nutritionist** (2010) Weiss, W. P. http://www.extension.org/pages/22405/energetics-for-the-practicing-nutritionist
- **Refining the Net Energy System** (2010) Weiss, W. P. http://www.wcds.ca/proc/2010/Manuscripts/p191-202Weiss.pdf

1.3 Protein and Amino Acids Requirements

The protein and amino acids requirements of the dairy cow are expressed in terms of metabolizable protein (MP) due to our current knowledge of nitrogen metabolism in dairy cattle. (MP) is true protein that flows from the rumen and is digested and absorbed from the small intestine as amino acids. These amino acids are the required nutrients that are metabolized by the cow to support maintenance, growth, reproduction and milk production.

Feed protein digested by the ruminal microbes is referred to as rumen-degradable protein (RDP), while protein that escapes microbial digestion is referred to as rumen-undegradable protein (RUP). Metabolizabe protein absorbed by the cow is a combination of RUP, microbial protein synthesized from RDP in the rumen, and a small amount of endogenous or recycled protein.

Microbial growth in the rumen is optimized when RDP and fermentable carbohydrates are available at all times. Rations where RDP and fermentable carbohydrates are unbalanced lead to inefficient use of feed protein and elevated nitrogen waste. Milk urea nitrogen (MUN) concentrations may be used to indicate how much nitrogen a lactating dairy cow is wasting.

Excess ammonia (NH3) in the rumen results when there is excess nitrogen for the ruminal microbes to use. Ammonia enters the cow's bloodstream and is converted to urea by the kidneys and liver. When the concentrations of urea in the blood increase, MUN also increases, serving as an indicator of inefficient nitrogen utilization in the animal.

Photo provided by Leandro Abdelhadi

1.3 Protein and Amino Acids Requirements

Considerations

- Use the metabolizable protein system to formulate rations that supply adequate rumen degradable protein (RDP) and rumen undegradable protein (RUP) for each dairy cattle group on the farm
- Consider using non-protein nitrogen (NPN) to partially supply RDP requirements
- Consider using sources of RUP and/or rumen-protected amino acids to more accurately supply limiting amino acids to improve productivity, reduce waste and potentially reduce diet cost
- Monitor milk urea nitrogen (MUN) concentration in groups of cows consuming the same diet to assess nitrogen waste and success of nitrogen capture and utilization by the cow

Resources

- **Balancing Diets for Amino Acids: Nutritional, Environmental and Financial Implications** (2010) Schwab, C. G. http://tristatedairy.osu.edu/Proceedings%202010/Chuck%20Schwab%20paper.pdf
- **Challenges in Protein Nutrition for Dairy Cows** (2006) Doepel, L. et al. http://www.wcds.ca/proc/2006/Manuscripts/Doepel.pdf
- **Feeding Low Crude Protein Rations to Dairy Cows – What Have We Learned?** (2012) Chase, L. et al. http://dairy.ifas.ufl.edu/rns/2012/3ChaseRNS2012.pdf
- **Protein and Amino Acids** (2001) National Research Council. In: Nutrient Requirements of Dairy Cattle, Seventh Revised Edition (pp. 43–104) http://www.nap.edu/openbook.php?record_id=9825
- **Why Use Metabolizable Protein for Ration Balancing?** (2010) Varga, G. A. http://www.extension.org/pages/26135/why-use-metabolizable-protein-for-ration-balancing

1.4 Ingredient and Diet Nutritional Analysis

The nutritional value of feed ingredients defines their ability to support animal performance. Laboratory analyses of feed ingredients for nutrient composition and digestibility allow for their best use in a ration that is formulated to meet the specific needs of an animal group without under- or over-feeding nutrients.

Dairy cattle are adapted to relatively high-fiber diets. Forage is usually a major contributor of fiber in dairy cow diets. Forages are in many cases home grown, and extensive forage use can minimize the need to import nutrients onto the farm. Forages, however, are subject to the greatest variability in nutrient composition and digestibility.

Ration formulation for dairy cattle should first seek to meet fiber requirements for rumen health, appropriately maximize forage use, and include sufficient concentrates and supplements (i.e., minerals and vitamins) to meet specific nutrient requirements.

The two main classes of carbohydrate are:

1. neutral detergent fiber (NDF)
2. non-fiber carbohydrate (NFC)

Chemical analysis with a neutral detergent solution is used to measure NDF. The NDF fraction includes cellulose and hemicellulose, plus the indigestible compound lignin. High-producing cows with a well-functioning rumen are limited in forage intake by the bulkiness of the fiber that fills up the rumen and/or slows the rate of passage. This bulkiness is best estimated by the forage NDF content and NDF digestibility.

NFC is a very diverse fraction containing organic acids, sugars, starches, fructans and pectins. The NFC fraction is commonly calculated as 100% − (CP% + NDF% + EE% + Ash%), where CP = crude protein, NDF = neutral detergent fiber and EE = ether extract. NFC provides energy to rumen microbes, which in turn produce volatile fatty acids as an energy source for the cow.

Starch provides between 20 to 30 percent of ration dry matter in lactating cow rations. Starch is commonly supplied by corn, sorghum, other small grains, silages and by-products, potatoes and bakery waste. Many factors, including sources, particle size and processing, cause starch digestibility to range from fast to slow.

Sugars typically make up three to eight percent of the ration dry matter and are typically supplied by molasses, citrus pulp, bakery waste, fresh forages or hay.

Neutral detergent soluble fibers include pectins, fructans and other soluble fibers that ferment quickly without the risk of acidosis. These soluble fibers are typically supplied from legume forages, citrus pulp and beet pulp.

Protein, made up of amino acids, is important for milk production, body maintenance and reproduction. CP (nitrogen x 6.25) is fractionated according to its rate of degradation in the rumen. Soluble protein (Fractions A + B1) is rapidly available. The soluble protein fraction includes non-protein nitrogen (NPN) such as urea. Protein fractions B2 and B3 are slowly available in the rumen. Acid detergent insoluble protein (Fraction C) is indigestible.

Fats make up two to six percent of the diet dry matter in dairy rations. Fats are added to the rations of high-producing cows to supplement the NEL when feed intake might limit milk production. Sources of fat added to diets of dairy cows include high-fat by-product feeds, oilseeds, animal fats and granular inert fats.

1.4 Ingredient and Diet Nutritional Analysis

Considerations

- Diet ingredients should be routinely analyzed at a laboratory for nutrient content and digestibility
- Improvements in fiber digestion can reduce reliance on other carbohydrate sources
- Multiple protein and carbohydrate sources should be available to allow for precise ration balancing

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1.4 Ingredient and Diet Nutritional Analysis

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Considerations

- Pay particular attention to starch concentration and digestibility for control of acidosis and reduction of energy losses from the cow
- Ration models which utilize multiple protein and carbohydrate fractions and estimate their extent of digestion for prediction of cow response should be used regularly for diet formulation

Resources

- **Dry Matter Determination** (2007) Nennich, T. et al. http://www.extension.org/pages/11315/dry-matter-determination
- **Forage Sampling Frequency as Influenced by Dairy Herd Size** (2010) Hoffman, P. et al. http://fyi.uwex.edu/forage/files/2014/01/ForageSamplingFrequency-FOF.pdf
- **Nutrient Variability in Feeds within Farms** (2012) Weiss, W. et al. http://ansci.cornell.edu/pdfs/cnc2012_Weiss.txt.pdf
- **Optimizing Starch Concentrations in Dairy Rations** (2005) Grant, R. http://tristatedairy.osu.edu/Grant%20paper.pdf
- **Relative Forage Quality** (2010) Undersander, D. et al. http://fyi.uwex.edu/forage/files/2014/01/RFQ-FOF.pdf

1.5 Dry Matter Intake and Feed Efficiency

Higher productivity per unit of feed intake is desirable to increase profitability and reduce enteric methane emission per unit of fat- and protein-corrected milk. Feed efficiency (FE) is often calculated for lactating cattle by dividing the amount of fat- and protein-corrected milk produced by the amount of dry matter intake (DMI).

This approach ignores factors that affect feed efficiency such as the NEL concentration of feed DM, changes in body weight, cold and heat stress, days in milk (DIM), and feed digestibility. It is, however, still useful for environmental and economic benchmarking, especially when used in combination with income over feed cost (IOFC) and income over purchased feed cost (IOPFC).

Improvements in FE can be achieved by increasing milk production while holding DMI constant or by holding milk production constant and decreasing DMI. Situations exist, generally due to compromised rumen health or inadequate ration formulation or feed processing, where DMI is not depressed but digestion is not optimal resulting in lower milk production and poor FE.

Increasing FE makes both economic and environmental sense because less dietary energy will be wasted as enteric methane and lower amounts of nutrients will be excreted into the environment in manure.

1.5 Dry Matter Intake and Feed Efficiency

Considerations

- Calculate dry matter intake (DMI), feed efficiency (FE), income over feed cost (IOFC) and income over purchased feed cost (IOPFC) and compare over time and with current recommendations
- Maximize overall diet digestibility for highest feed efficiency
- Promote dry matter intake (DMI), especially in early lactation, by feeding forages containing highly digestible fiber and improving the cow's transition into lactation from the dry period

Resources

- **Increasing Efficiency of Nutrient Use to Enhance Profit and Environmental Stewardship** (2011) VandeHaar, M. J. http://dairy.ifas.ufl.edu/rns/2011/1vandehaar.pdf
- **Major Advances in Nutrition: Relevance to the Sustainability of the Dairy Industry** (2006) VandeHaar, M. et al. http://dx.doi.org/10.3168/jds.S0022-0302(06)72196-8
- **Mitigation of Enteric Methane Emissions Through Improving Efficiency of Energy Utilization and Productivity in Lactating Dairy Cows** (2010) Yan, T. et al. http://dx.doi.org/10.3168/jds.2009-2929
- **Practical Approaches to Feed Efficiency and Applications on the Farm** (2007) Hutjens, M. F. http://extension.psu.edu/animals/dairy/courses/dairy-cattle-nutrition-workshop/previous-workshops/2007-nutrition-workshop

1.6 Feeding Management

Feeding management is the last necessary step of a feed program that successfully promotes optimal productivity, profits and mitigation of enteric methane emissions. The non-dietary factors associated with feed mixing, delivery and consumption can explain a large portion of variability in DMI, milk production, FE, IOFC, profits and enteric methane emissions per unit of fat- and-protein-corrected milk.

Feeding management is concerned with the delivery of a balanced ration in the appropriate amounts, forms and times to the animals. The purpose of feeding management is to accurately and repeatedly provide feed in an environment that promotes healthy feeding behaviors. This is achieved by daily evaluation of dairy feed mixing and delivery, feed refusal, and animal productivity and status, including daily pen populations. Use of feed management software, training and employee incentives that align with measured and desired outcomes, are effective tools for successful feeding management.

1.6 Feeding Management

Considerations

- Avoid overcrowding by monitoring and adjusting stocking density (number of freestalls per cow)
- Deliver fresh feed after milking to promote standing and reduce the risk of mastitis
- Delivering fresh feed more frequently (two times a day or more) stimulates eating behavior, reduces sorting and avoids slug feeding (rapid consumption of large amounts of concentrate in one meal)
- Encourage measuring feed ingredient weights accurately and following mixing equipment directions (for example, mixing time and staying within mixer load capacity limits)
- Establish a routine or procedure for consistently mixing and delivering feed every day
- Examine feed refusals for evidence of extensive feed sorting and selective consumption of concentrate
- Frequent feed push-up (pushing feed closer to animals between feedings to provide continuous access) also stimulates eating but to a lower extent than fresh feed delivery
- Monitor and record feed delivery and refusals by pen daily, preferably with feed management equipment and software
- Provide sufficient bunk space, preferably with a physical partition (for example, headlocks) to allow animals to eat simultaneously
- Train employees and evaluate their performance according to the established feed mixing and delivering procedures
- Use feed management software and equipment to monitor and evaluate feed shrink, procedures and the influence of personnel and facilities on feed management

Resources

- **Associations Between Nondietary Factors and Dairy Herd Performance** (2008) Bach, A. et al. http://dx.doi.org/10.3168/jds.2008-1030
- **Impact of Feeding Management on Cow Behaviour, Health, and Productivity** (2013) DeVries, T. J. http://www.wcds.ca/proc/2013/Manuscripts/p%20193%20-%20204%20DeVries.pdf
- **Stocking Density and Feed Barrier Design Affect the Feeding and Social Behavior of Dairy Cattle** (2006) Huzzey, J. M. et al. http://dx.doi.org/10.3168/jds.S0022-0302(06)72075-6
- **Using Feedstuff Inventory Management and Feeding Management Software on the Dairy: Concepts and Tasks** (2009) Jamison, C. A. http://tristatedairy.osu.edu/Proceedings%202009/Jamison%20paper.pdf

1.7 Drinking Water Quality and Access

Water is the most important essential nutrient required by dairy cattle and is especially important in lactating cows. Consequently, drinking water quality and accessibility are very important components of successful feeding management programs.

Free and easy access to plentiful sources of high-quality and clean drinking water is absolutely essential for optimum production and profits. Water intake also lowers enteric methane emissions by dairy cattle.

1.7 Drinking Water Quality and Access

Considerations

- Always provide multiple sources of plentiful drinking water located in accessible alleys with sufficient space for cows to move around them easily
- Collect drinking water samples and submit for laboratory analysis (including mineral analysis) on a routine basis or when a new water source is used or quality issues are suspect
- Compare measured water intake to predicted requirements for the level of productivity
- Locate drinking water troughs near feed troughs and within 50 feet of all stalls
- Monitor drinking water intake with in-line water meters installed in each water source and include water intake from feed in the total water consumption estimates
- Monitor water cleanliness on all troughs daily and clean as required
- Provide 1 to 2 feet of linear trough space in return alleys from the milking parlor to promote water consumption immediately after milking
- Relatively shallow watering troughs that are easy to clean and refill quickly with warm water are preferred

Resources

- **Evaluation of Water Quality and Nutrition for Dairy Cattle** (2006) Beede, D. K. http://www.highplainsdairy.org/2006/Beede.pdf
- **Scientific Data for Developing Water Budgets on a Dairy** (2013) Harner, J. et al. http://www.wdmc.org/2013/Scientific%20Data%20for%20Developing%20Water%20Budgets%20on%20a%20Dairy.pdf
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Chapter 2: Forage Management

Chapter Content

2.1 Forage Importance and Contributions
2.2 Grazing
2.3 Forage Establishment and Growth
2.4 Forage Harvest and Processing
2.5 Forage Storage
   a. Hay
   b. Silage
2.6 Forage Feedout

Introduction

High-quality forage promotes feed intake, overall ration digestibility and high productivity, leading to more profits and reduced enteric methane emissions per unit of fat- and -protein-corrected milk. Forage management also adds financial value by significantly influencing animal health and performance, feed utilization and costs, and land and nutrient management on dairy farms.

Homegrown forages or forages produced locally by neighbors and partners are ideal for use on dairy farms because they can provide a substantial nutrient base that cost-effectively uses available resources. Forage quality is dependent on field conditions, plant species and variety, fertilization, maturity at harvest or during grazing, length of cut, processing, and preservation. To improve animal performance and reduce enteric methane emissions, emphasis is placed on reducing digestible dry matter losses at harvest, during storage and feedout.

2.1 Forage Importance and Contributions to the Diet

Forages are very important in dairy cattle diets. In many rations, they contribute more than half of the total dietary DMI and can supply several nutrients including energy, protein, starch and minerals. Forages are usually major contributors of dietary NDF.

Total dietary NDF content and digestibility are directly related to methane formation in the rumen, rumen function maintenance and feed intake regulation — all significant factors that determine productivity and enteric methane emissions. Consequently, the potential for

forage composition and digestibility to improve performance and reduce emissions needs to be considered within the context of the whole diet.

The composition and digestibility of forages are more variable than that of any other feed ingredient in dairy cattle diets. Compositional and digestibility analyses, therefore, are critical to understand and manage forage variability in ration formulation and feeding for all animal classes in the dairy herd, (see 1.4 Ingredient and Diet Nutritional Analysis).

Forage quality depends on composition and digestibility, but is ultimately expressed by its ability to support high levels of animal performance. The greatest benefits in terms of improving productivity, while reducing enteric methane emissions per unit of milk, occur with high intakes of highly digestible forages.

Lactating dairy cows have the greatest nutrient demand than any other class of animal on the dairy farm and benefit the most from including high-quality forage in their diets. Feeding higher-quality forage to lactating cows usually increases milk production while reducing the need for supplemental concentrate in their diet.

The production, storage and feeding of high-quality forage can reduce the need for off-farm feed purchases, thus mitigating rising feed costs and improving profitability. Also, on-farm forage production influences land-use decisions and whole-farm nutrient balance, offering potential solutions to environmental management challenges faced by intensively managed dairy farms.

Forages are the foundation of nutritionally-sound dairy cattle diets.

Photo provided by Leandro Abdelhadi

2.1 Forage Importance and Contributions to the Diet

Considerations

- Analyze forages for nutrient composition and NDF digestibility regularly
- Establish a forage management system that takes into consideration available land base, agronomic conditions, harvest methods, storage systems, feeding strategies and whole-farm nutrient balance
- Maximize use of forage resources by feeding to various animal classes according to their nutrient demands and forage analyses results
- Strive to produce the largest quantity of high-quality forage for the available land base in a cost-effective manner

Resources

- **Creating a System for Meeting the Fiber Requirements of Dairy Cows** (1997) Mertens, D. R. Journal of Dairy Science 80:1463–1481. http://dx.doi.org/10.3168/jds.S0022-0302(97)76075-2
- **Feeding Quality Forages to Improve Profits with Dairy Cattle** (n.d.) Pennington, J. http://www.uaex.edu/Other_Areas/publications/PDF/FSA-4010.pdf
- **Focus on Forage** University of Wisconsin - Extension. http://fyi.uwex.edu/forage/fof/
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- **Using Forages in Dairy Rations: Are We Moving Forward?** (2009) Cherney, D. et al. http://www.ansci.cornell.edu/pdfs/cnc09web.pdf

2.2 Grazing

Although grazing systems require different management approaches to confined-feeding systems, the considerations relative to forage management are similar for both. Grazing systems should also target high animal productivity to increase profitability and reduce enteric methane output per unit of fat- and -protein-corrected milk.

Because some areas have snow cover for several months, year-round grazing systems may not be feasible and must be considered when planning the overall planting and grazing schedule. Grazing forages at the maturity, which provides the best combination of nutrient content and digestibility, is highly desirable and requires careful pasture management.

2.2 Grazing

Considerations

- A key feature of high-quality pasture is the high rate of fiber degradation, which is associated with intense rumen fermentation and high milk yields
- Apply manure and commercial fertilizer according to soil analyses and the nutrient needs of each pasture
- Avoid grazing very wet soils
- Consider mechanical treatments such as pitting, contour furrowing, chiseling, ripping or subsoiling to modify soil and address natural resource concerns prior to planting
- Consider selective breeding of dairy cows better-suited to diets of grazed pasture to maximize efficiency of grazing program
- Consider strategic supplementation with concentrates
- Consider using legumes in warm climates to replace C4 grasses (warm-season grasses)
- Estimate pre-grazing herbage mass and post-grazing sward height to target pre-grazing herbage mass allowance that optimizes intake and performance
- Increase the efficiency of utilization of grazed forage crops via controlled rotational grazing or management-intensive grazing
- Time grazing to optimize plant maturity and provide the best combination of nutrient content and digestibility from each pasture

Resources

- **Effect of Pregrazing Herbage Mass on Methane Production, Dry Matter Intake, and Milk Production of Grazing Dairy Cows During the Mid-Season Period** (2010) Wims, C. M. et al. http://dx.doi.org/10.3168/jds.2010-3245
- **Grazier's Notebook** University of Wisconsin - Extension. http://fyi.uwex.edu/forage/g-n/
- **Grazing Land Mechanical Treatment: Conservation Practice Standard 548** NRCS (n.d.) http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/?cid=nrcs143_026849
- **Invited Review: Production and Digestion of Supplemented Dairy Cows on Pasture** (2003) Bargo, F. et al. http://dx.doi.org/10.3168/jds.S0022-0302(03)73581-4
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- **Prescribed Grazing: Conservation Practice Standard 528** NRCS (n.d.) http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/?cid=nrcs143_026849
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- **Profitable Grazing-Based Dairy Systems** (2007) NRCS, USDA-Natural Resources Conservation Service http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044245.pdf
- **Range Planting: Conservation Practice Standard 550** NRCS (n.d.) http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/?cid=nrcs143_026849

2.3 Forage Establishment and Growth

<u>Alfalfa and Other Legumes:</u> Three key management details for the establishment of alfalfa or other legumes are:

1. proper soil pH
2. properly firmed soil
3. accurate planting depth

Fields can be direct-seeded, but seeding forage grasses with legumes can help limit soil erosion. This keeps nutrients in place, reducing the amount of fertilizer needed and improving the farm manure management plan.

<u>Grasses:</u> Well-managed grasses can improve overall ration fiber digestibility and nutrient management, and reduce soil erosion. Established grasses also provide a convenient place for in-season applications of manure and reduce the need for commercial fertilizer application.

Grasses are much less sensitive to wheel traffic than alfalfa and will greatly benefit from the nitrogen in manure. Grass management, however, can be more difficult than alfalfa management because grasses lose quality quickly after heading. When seeded with alfalfa, it is important to select a grass variety that matures at a similar time as the alfalfa matures. The ideal is to have the grass in the late boot (preheading) stage at the same time as the alfalfa is in the late boot (pre-flowering) stage.

<u>Corn Silage:</u> Most corn hybrids planted for silage harvest are conventional hybrids, which vary in yield, grain content and fiber digestibility. Corn hybrids should be selected based on hybrid maturity, traits (see the three above), and their performance in replicated trials.

Seed companies are the most reliable source of maturity information on their hybrids. Fiber (NDF) digestibility is important, but corn silage contains substantial amounts of energy-dense starch (30 percent on average), so starch yield is a very important factor in hybrid selection. Maturity, seed treatments, technology traits, planting population and chop height must all be the same for meaningful corn hybrid comparisons. Seek out as much information from the seed company as possible to ensure proper planting date, target plant population and fertility program best-suited to the particular hybrid of choice.

Fertilizer applications should always be based on a recent soil analysis. Manure can provide a large proportion of the plant's nutrient needs. Supplemental commercial fertilizer can be used for the remainder.

Forage crop yields and quality can be significantly reduced by weed growth, pest infestation and disease. Effective weed, disease and pest control begins with proper soil and growing conditions. Selection of resistant plant varieties or hybrids is also an important factor for successful weed and pest control.

Vigorous forage crop growth is the most important factor to control weed infestation. Monitoring the forage crop growth and insect and weed pressure is essential for all forage crops. Having an action plan to act quickly and accordingly to the specific type of crop, disease and infestation is important. Always follow manufacturers' recommendations when applying herbicides and pesticides to ensure appropriate application rates and timing.


Photo provided by Leandro Abdelhadi

2.3 Forage Establishment and Growth

Considerations

- Conduct regular soil analyses and target manure and commercial fertilizer applications accordingly
- Determine the optimum combination of legume, grass and corn silage acres to best fit growing conditions, ration needs and nutrient waste management requirements
- Evaluate corn silage hybrid research results prior to purchasing seed
- Follow herbicide and pesticide manufacturers recommendations to ensure proper application rates and timing
- Follow seed company recommendations for optimum growth conditions
- Monitor growth and pressure from weeds and insects to spot problems early and take corrective action
- Select plant varieties based on yield, days to maturity, geographic location, planned use, winter hardiness and disease resistance

Resources

- **Alfalfa Management Guide** (2011) Undersander, D. et al. https://www.agronomy.org/files/publications/alfalfa-management-guide.pdf
- **Forage and Biomass Planting: Conservation Practice Standard 512** (n.d.) NRCS http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/?cid=nrcs143_026849
- **Forage Crops—Crops and Soils** Penn State Extension. http://extension.psu.edu/plants/crops/forages

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2.3 Forage Establishment and Growth

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Resources

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- **Successful Forage Establishment** Penn State Extension. http://extension.psu.edu/plants/crops/forages/successful-forage-establishment
- **Team Forage** University of Wisconsin-Extension. http://fyi.uwex.edu/forage/

2.4 Forage Harvest and Processing

Highly digestible forages, which help to reduce grain levels in the ration, improve rumen health and reduce ration costs. Michigan State University research showed that increasing *in vitro* or *in situ* NDF digestibility of ration forage by one percentage point increases DMI by 0.37 pounds. (0.17 kg) and four percent fat-corrected milk production by 0.55 pounds (0.25 kg) per day.

A number of factors influence NDF digestibility. Legumes have less total NDF than grasses, but due to greater lignification, their NDF digestibility is lower than in grasses. Grasses, including corn silage, have less lignin but large ranges in maturity, contributing to a large range in NDF digestibility.

As plants mature, their NDF content and lignification increases and their NDF digestibility decreases. This maturation process can occur quite rapidly in grasses, making harvest timing and speed critical.

Cows need fiber to maintain optimum rumen function. Forages must provide adequate amounts of long, chewable (effective) fiber, which induces saliva production to buffer the organic acids produced from the digestion of carbohydrates in the rumen. Fiber also stimulates the movement of rumen contents to increase the absorption of organic acids from the rumen.

Corn silage provides both fiber and starch to the diet. Proper corn silage processing at harvest is essential for increasing starch digestibility and reducing the need for additional grain in the ration. It is generally recommended that corn silage be cut at a 0.75-inch (1.9 cm) theoretical length of cut and that a 1/8-inch (2 to 3 mm) roller clearance be maintained so that all corn kernels are crushed **(see Figure 2)**.

Forage Crop	Coarse > 0.75 in. (1.9 cm)	Medium	Fine < 0.3 in. (0.8 cm)
Processed Corn Silage	20-25%	30-40%	35-50%
Unprocessed Corn Silage	10-15%	35-45%	35-45%
Hay Crop Silage	20-25%	30-40%	35-50%
Total Mixed Ration	10-15%	30-50%	40-60%

Figure 2: Recommendations for Particle Size Using the Penn State Particle Size Separator

2.4 Forage Harvest and Processing

Considerations

- Adequately size and maintain harvesting equipment to avoid harvest delays
- Analyze forages for nutrient composition and NDF digestibility and target feeding to various animal classes according to their nutrient demands
- Check forages at time of harvest for length of cut and extent of kernel processing and adjust harvesting equipment as necessary
- Harvest all forages at the proper moisture for the chosen method of preservation—hay, wrapped baleage, bunker silo, tower silo and oxygen-limiting silo
- Harvest all forage types at the recommended maturity to optimize digestibility without greatly compromising yield
- Harvest forages at an appropriate length to stimulate cud chewing in the cow yet still optimize silage packing density
- If silage length is not adequate, provide other sources of long fiber in the ration such as coarsely chopped hay or straw
- Utilize a corn silage processor to increase kernel starch digestibility

Resources

- **Evaluation of the Importance of the Digestibility of Neutral Detergent Fiber From Forage: Effects on Dry Matter Intake and Milk Yield of Dairy Cows** (1999) Oba, M. et al. http://dx.doi.org/10.3168/jds.S0022-0302(99)75271-9
- **Forage And TMR Particle Size and Effects on Rumen Fermentation of Dairy Cattle** (2012) Kononoff, P. et al. http://www.extension.org/pages/11319/forage-and-tmr-particle-size-and-effects-on-rumen-fermentation-of-dairy-cattle
- **Forage Harvest Management: Conservation Practice Standard 511** NRCS (n.d.) http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/?cid=nrcs143_026849
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- **The Penn State Particle Separator (DSE 2013-186)** (2013) Heinrichs, J. http://extension.psu.edu/animals/dairy/nutrition/forages/forage-quality-physical/separator/extension_publication_file
- **Utilization of Starch From Silages** (2007) Weiss, W. P. et al. http://txanc.org/wp-content/uploads/2011/08/Weiss-manuscript-final-2007.pdf

2.5 Forage Storage

Biological degradation processes that decrease forage nutrient content begin as soon as forage crops are cut. The primary goal of storage is the preservation of nutrient quality present in harvested forage crops.

Preservation is usually achieved through drying (haymaking) or ensiling forage crops. The choice of method depends on various factors, with weather being the most significant.

Haymaking: The goals in haymaking are to stop growth of all bacteria and molds and limit chemical reactions by drying the forage below 20 percent moisture content. Hay baled too wet has a higher risk of mold growth and loss of dry matter, nutrients and energy. Also, wet hay has a higher risk for spontaneous combustion. Very dry hay may have a higher level of leaf shattering conducive to protein loss.

Ensiling: The preservation of nutrients is achieved during ensiling by acidification and the exclusion of oxygen (air). Silage has to be compacted quickly and sealed effectively to achieve high density, exclude oxygen and allow lactic acid bacteria fermentation to reduce the pH quickly.

A silage inoculant is a management tool used to enhance silage fermentation. Commercial inoculants usually contain two or more types of bacteria: homofermenters (such as *Lactobacillus spp.*) that only produce lactic acid and increase the rate of pH reduction, and heterofermenters (such as *L. buchneri*) that produce both lactic and acetic acids and keep silage fresh longer after feedout (i.e., increased aerobic stability). Enzymes may also be incorporated into silage inoculants to help break down complex carbohydrates and promote the silage fermentation process.

Forages stored as silage and dry hay can contribute more than 50 percent of the total ration's dry matter. Adequate storage influences quality and quantity of available forage.

Photo provided by Leandro Abdelhadi

2.5a Forage Storage – Hay

Considerations

- Bales wrapped too long after harvest tend to have lower forage quality and greater mold throughout the bales
- Evaluate research results of commercially available hay preservatives and apply the best for your situation at recommended rates using carefully calibrated equipment
- Make bales the size and weight suggested by the wrapper manufacturer as heavier bales are more prone to tears and punctures while wrapping, stacking and storing
- Preserve nutrient content of forage by minimizing leaf loss
- Prevent spontaneous combustion with adequate drying of forage prior to baling
- Target optimum hay dry matter to minimize spoilage

Resources

- **Forage Management; Proper Handling and Curing of Hay** (2002) Rayburn, E. http://www.wvu.edu/~agexten/pubnwsltr/TRIM/5811.pdf
- **Hay Additive Review: Where We've Been, Where We're Going** (1994) Mahanna, B. https://www.pioneer.com/CMRoot/Pioneer/US/products/alfalfa/pdfs/alfalfa_inoculants_hay_additive.pdf
- **Minnesota Dairy Initiatives - Dairy Diagnostics Tool Box Factsheet 1: Feed Storage Tables** (n.d.) http://www.ansci.umn.edu/prod/groups/cfans/@pub/@cfans/@ansci/documents/asset/ansci-dairydiag-fact-1.pdf
- **Silage and dry hay management** (2007) Seglar, W. J. http://www.extension.org/pages/11070/silage-and-dry-hay-management

2.5b Forage Storage – Silage

Considerations

- Allow enough time for complete forage fermentation (especially corn silage) prior to feedout to optimize intake and digestibility
- Analyze silages for VFA content (primarily lactic, acetic, propionic and butyric acids) to assess silage quality
- Calculate the necessary tractor weight for effective packing of incoming forage and monitor achieved packing density
- Conduct dry matter (DM) analyses of bagged silages and adjust feed rations when DM content changes more than two percentage units

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2.5b Forage Storage - Silage

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Considerations

- Consider best type, size and number of storage structures to contain all harvested forage
- Evaluate research results of commercially available forage inoculants and apply the best for your situation at recommended rates using carefully calibrated equipment
- Evaluate research results of commercially available silage plastic cover options
- Fill the silo quickly, pack well and seal effectively
- Limit oxygen penetration of silage at time of feedout to minimize secondary fermentation and associated losses
- Skilled labor for a bagging machine is essential to ensure consistent and uniform fill with acceptable density
- Store highly digestible forages separately to optimize usage
- The optimum moisture content for storing haylage as bales is between 40 and 55 percent, which lowers DM losses and creates ideal conditions for fermentation and longer-term storage of wrapped bales

Resources

- **Corn Silage Management** (2013) Schroeder, J. http://www.ag.ndsu.edu/pubs/ansci/dairy/as1253.pdf
- **Dairy Focus: To Inoculate or Not To Inoculate** (2011) Schroeder, J. http://www.ag.ndsu.edu/news/columns/dairy-focus/dairy-focus-to-inoculate-or-not-to-inoculate
- **From Harvest to Feed: Understanding Silage Management** (2004) Jones C. M. et al. http://pubs.cas.psu.edu/freepubs/pdfs/ud016.pdf
- **Help in choosing an effective silage inoculant** (2014) Kung, L. J. http://www.extension.org/pages/11767/help-in-choosing-an-effective-silage-inoculant#.U6s9UHkU9jo
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- **Sealing Strategies for Bunker Silos and Drive-over Piles** (2006) Berger L. L. et al. http://www.ksre.ksu.edu/pr_silage/publications/NRAES%20Berger%20%26%20Bolsen%20Sealing%20Strategies%204-14-06.pdf
- **Silage and dry hay management** (2007) Seglar, W. J. http://www.extension.org/pages/11070/silage-and-dry-hay-management
- **Silage Management Considerations** (2007) Bolsen K. K. et al. http://puyallup.wsu.edu/dairy/nutrient-management/data/publications/SilageMgtFinal.pdf
- **Silage Zone® Manual** (2014) Mahanna B. et al. https://www.pioneer.com/home/site/canada/template.CONTENT/guid.45B9E891-3188-085C-6A48-C2B6A5D7F604

2.6. Forage Feedout

Losses in forage DM occur at all stages of the preservation process and contribute to feed shrink. Losses that reduce profitability and increase environmental impact can be extremely variable from farm to farm. Shrink can account for 20 to 30 percent of the forage crop standing DM from harvest to feeding.

Mechanical handling and weather damage in the field cause the majority of the losses in haymaking. Leaf loss is greater than stem loss, reducing both forage amount and quality since leaves are more protein and energy-dense than stems.

Ensiling converts readily available soluble carbohydrates to lactic acid, thus reducing the quality of the harvested forage crop. Nutrient losses in silages are most prominent during storage and feedout. Silage feedout face management is extremely important to minimize these losses.

Feedout face management is mostly concerned with maintaining a smooth and perpendicular surface to minimize silage surface area exposure to air. Silage face removal rate is another important factor in feedout management. Discarding aerobically spoiled silage during feedout prevents reducing the nutritive value of the silage-based ration and animal performance.

2.6 Forage Feedout

Considerations

- Adjust equipment to maintain high density while bagging to lower the amount of entrapped air and rate of air infiltration when opening or if punctured
- Assess and make adjustments as needed for available equipment and labor to harvest, transport, fill and cover silage storage facilities rapidly to reduce exposure to air
- Closely estimate the amount of forage needed to minimize waste and variation for all feedout methods
- Conduct regular inspection and maintenance of silos to minimize exposure to air and precipitation
- Silage fed in warmer weather deteriorates faster than silage fed in colder weather
- When using bagged storage, uncover only what will be used for each feeding and close the bag after each feeding to reduce losses caused by reintroduction of oxygen

Resources

- **Determining Your Current Forage Inventory** (2012) Chase L.E. et al. http://www.ansci.cornell.edu/pdfs/DetForageInventory.pdf
- **Feed Inventory—Charts, Tables and Formulas** (n.d.) Cropp, B. http://cdp.wisc.edu/pdf/Feed%20charts.pdf
- **Feedout Losses from Forage Storage Systems** (2008) Clark, J. et al. http://fyi.uwex.edu/forage/files/2014/01/FeedoutLossFOF.pdf
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Chapter 3: Concentrate Management

Chapter Content

3.1 Carbohydrates
3.2 Proteins (Amino Acids)
3.3 Lipids
3.4 By-product Feeds
3.5 Feed Additives

Introduction

Concentrate management significantly influences animal health, performance, feed utilization and costs. By directing rumen fermentation away from methane-producing pathways, concentrates (e.g., grains, oilseeds and by-product feeds) added to dairy cattle rations also reduce enteric methane emissions per unit of fat- and -protein-corrected milk.

A large portion of concentrates are typically purchased and included in the diet to provide extra energy, protein and other macronutrients and micronutrients that may be insufficient in the forage base. In many cases, concentrates also serve as the vehicle for supplements and feed additives. Concentrates are usually fed in mixes containing a variety of ingredients. The type of concentrate mix fed is contingent on the forage base, the animal class and target productivity, and the availability and cost of ingredients. While concentrate feeding helps reduce enteric methane emissions, feeding large amounts of concentrate in a diet with insufficient fiber may lead to ruminal acidosis and milk fat depression. These conditions reduce performance, profits and the emission-mitigating effects. The objective is to strategically feed concentrates in a balanced diet to ensure high levels of health and performance from every feed unit offered to dairy cattle.

3.1 Carbohydrates

Concentrate feeds can be fed to supply energy in dairy cattle diets in the form of carbohydrates (i.e., starch, sugar, soluble fiber and highly fermentable non-forage NDF). The objective is to balance the ratio of rumen-degraded carbohydrates relative to dietary effective fiber. Although NFC is commonly used in ration formulation

(see 1.4 Ingredient and Diet Nutritional Analysis for NFC definition and calculation), it is a diverse fraction that includes various types of carbohydrates that differ in terms of ruminal digestibility and fermentation end products. Consequently, understanding the type of carbohydrates that can be fed helps to determine how concentrate feeding aids a balanced diet.

Starch: Concentrates used to supply dietary starch include corn, sorghum, barley, wheat, oats and bakery and grain by-products (such as wheat midds and corn gluten feed). A high extent of starch availability is desired, but a combination of rapidly and slowly available starches will help with acidosis control and optimization of microbial growth. Grinding increases surface area and aids starch digestibility.

Gelatinization increases the speed with which enzymes and microbes can break down the linkages of starch to yield energy and microbial protein. Gelatinization is caused by a combination of moisture, heat, mechanical energy and pressure. The feed industry uses steam flaking, extrusion and pelleting to gelatinize starch.

Sugars: Sugars can improve ration palatability. Sugars provide a quickly digestible source of energy in the rumen to facilitate microbial utilization of rapidly available nitrogen. In this way, sugar can help to reduce nitrogen wastage in the form of urea. Concentrates commonly used as sugar sources include molasses, citrus pulp, beet pulp and bakery waste.

Non-forage NDF: To provide energy while also improving rumen health, it may be desirable to replace some dietary starch with non-forage NDF from ingredients such as soy hulls, beet pulp or citrus pulp. Beta-glucans, galactans and pectins (also referred to as soluble fiber), can provide energy yet ferment to form the weaker acid called acetate, which reduces rumen acidosis. Soy hulls also contain NDF, which ferments to acetate.


Photo provided by Leandro Abdelhadi

3.1 Carbohydrates

Considerations

- Balance NFC to dietary NDF (see 1.4 Ingredient and Diet Nutritional Analysis) according to the various types (starch, sugar, soluble fiber and non-forage NDF) and amounts of NFC in the concentrate
- Consider use of any available, economical starch sources with known nutrient composition and digestibility characteristics
- Consider using sources of highly fermentable, non-forage NDF to partially replace both starch and less-digestible NDF for improving rumen health and DMI
- Pay attention to starch processing and particle size to ensure a high extent of starch digestion without negatively impacting rumen pH
- Provide a combination of carbohydrate sources from concentrate to maximize diet digestibility and microbial protein synthesis in the rumen

3.1 Carbohydrates

Resources

- **Advancements in Feeding Carbohydrates** (2007) Eastridge, M. L. http://www.wcds.ca/proc/2007/Manuscripts/Maurice.pdf
- **Carbohydrate Nutrition for Lactating Dairy Cattle** (2001) Ishler, V. et al. http://extension.psu.edu/animals/dairy/health/nutrition/nutrition-and-feeding/diet-formulation-and-evaluation/carbohydrate-nutrition-for-lactating-dairy-cattle/view
- **Effect of Molasses Supplementation on the Production of Lactating Dairy Cows Fed Diets Based on Alfalfa and Corn Silage** (2004) Broderick, G. A. et al. http://dx.doi.org/10.3168/jds.S0022-0302(04)73431-1
- **High Methanogenic Potential of Sucrose Compared with Starch at High Ruminal pH** (2009) Hindrichsen, I. K. et al. http://dx.doi.org/10.1111/j.1439-0396.2007.00779.x
- **Liquid Feeds and Sugars in Diets for Dairy Cattle** (2011) Firkins, J. L. http://dairy.ifas.ufl.edu/rns/2011/7firkins.pdf
- **Optimizing Starch Concentrations in Dairy Rations** (2010) Grant, R. http://www.extension.org/pages/25687/optimizing-starch-concentrations-in-dairy-rations
- **Ruminal Acidosis in Dairy Cows: Balancing Physically Effective Fiber with Starch Availability** (2007) Beauchemin, K. A. http://dairy.ifas.ufl.edu/rns/2007/Beauchemin.pdf
- **Utilization of Starch from Silages** (2007) Weiss, W. P. et al. http://txanc.org/wp-content/uploads/2011/08/Weiss-manuscript-final-2007.pdf
- **Working with Non-NDF Carbohydrates with Manure Evaluation and Environmental Considerations** (2002) Hall, M. B. http://txanc.org/wp-content/uploads/2011/08/Non-NDF-Carbohydrates.pdf

3.2 Proteins (Amino Acids)

Nutritionists estimate MP plus amino acid delivery to the cow from estimates of RDP and RUP (see 1.3 Protein and Amino Acids Requirements for MP, RDP and RUP definitions).

Fine-tuning diets to meet, but not exceed, the cow's need for each of the 10 essential amino acids helps to reduce protein wastage, save purchased protein costs and increase yield of milk and milk protein. Proteins are chains of specific sequences of 50 or more amino acids. Milk protein production can be limited by one amino acid that is in short supply in relation to the cow's requirement. That amino acid is called the "first-limiting" amino acid in the diet and will depend upon the feed ingredients in the cow's ration. For dairy cows in North America, methionine and lysine are typically thought to be the most-limiting amino acids.

When ration-balancing, the goals should be to: 1) make as much rumen microbial protein as possible because its amino acid profile closely matches that of milk protein and it is economical; and 2) provide a proper blend of amino acids in RUP.

Many times rations appear to provide sufficient RUP, but a few amino acids in this RUP are limiting.

For example, if most of the RUP comes from corn protein, production is likely being limited by the amino acid lysine.

With advanced nutrition models, diets can be balanced for MP, RDP, RUP and amino acids using combinations of vegetable proteins such as corn and soy as well as small amounts of rumen-protected amino acids now available on the market.

Photo provided by Leandro Abdelhadi

3.2 Proteins (Amino Acids)

Considerations

- Consider use of any available, economical protein sources with known nutrient composition and digestibility characteristics
- Consider use of non-protein nitrogen sources to partially supply rumen nitrogen needs (RDP)
- Evaluate research on available rumen-protected amino acids and RUP and consider their use to supply limiting amino acids, improve productivity and reduce waste
- Formulate diets using an advanced nutrition model that predicts MP and amino acid supplies and requirements
- Optimize rumen microbial protein synthesis by maintaining optimum rumen health and synchronizing rates of protein and carbohydrate fermentation

Resources

- **Balancing Diets for Amino Acids: Nutritional, Environmental and Financial Implications** (2010) Schwab, C. G. et al. http://tristatedairy.osu.edu/Proceedings%202010/Chuck%20Schwab%20paper.pdf
- **Challenges in Protein Nutrition for Dairy Cows** (2006) Doepel, L. et al. http://www.wcds.ca/proc/2006/Manuscripts/Doepel.pdf
- **Current Status of Amino Acid Requirement Models for Lactating Dairy Cows** (2006) Hanigan, M. D. et al. http://tristatedairy.osu.edu/Hanigan.pdf
- **Feeding Low Crude Protein Rations to Dairy Cows – What Have We Learned?** (2012) Chase L.E. et al. http://dairy.ifas.ufl.edu/rns/2012/3ChaseRNS2012.pdf
- **The Principles of Balancing Diets for Amino Acids and Their Impact on N Utilization Efficiency** (2012) Schwab C. G. http://dairy.ifas.ufl.edu/rns/2012/1SchwabRNS2012.pdf
- **Why Use Metabolizable Protein for Ration Balancing?** (2010) Varga, G. A. http://www.extension.org/pages/26135/why-use-metabolizable-protein-for-ration-balancing

3.3 Lipids

Lipids (fats) are added to high-production dairy diets to supply a dense form of energy that does not ferment in the rumen. Typical lipid sources include vegetable oils, prilled fat, tallow, free fatty acids, calcium salts of fatty acids, granular rumen-inert fats and whole or crushed oilseeds (e.g., whole cottonseed, whole soybeans).

Feeding high-oil coproducts from the food, fiber and biofuel industries is a practical way to include lipids in dairy diets. This category of coproducts include processed soybeans, rapeseed, canola, flaxseed and other oilseeds, palm oil and distillers grains.

Lipid supplementation often improves conception rates by improving body condition of the cow and providing specific fatty acids needed for reproduction. Also, feeding organic oils of vegetable or animal origin is one of the most extensively studied practices for mitigating enteric methane from dairy.

Dietary lipids can reduce enteric methane but must be fed in appropriate quantities so that the ether extract (EE) or crude fat concentrations in the diet do not exceed seven percent of total DM to avoid negative consequences on feed intake, milk production and milk fat content.

High quantities of rumen-available lipid can impede fiber digestion by the rumen microbes. Excessive amounts of certain rumen-available fatty acids are known to reduce the concentration of fat in milk, decreasing the value of the milk for the farmer and processor. Typically, nutritionists take advantage of economical rumen-available lipid by taking it up to recommended limits and utilizing the more expensive rumen-inert fats if more energy or specific fatty acids are needed.

Photo provided by Leandro Abdelhadi

3.3 Lipids

Considerations

- Consider additional sources of lipid for increasing diet energy, especially if body condition and rates of conception are a concern
- Consider partial replacement of dietary carbohydrate with lipid to aid in control of subclinical rumen acidosis
- Evaluate research on available rumen-inert fat products to determine energy content, digestibility, fatty acids and expected production and reproduction responses
- Utilize an advanced nutrition model to calculate quantities of individual rumen-available fatty acids in the ration and avoid milk fat depression and fiber digestion consequences

3.3 Lipids

Resources

- **Calcium Salts are Highly Digestible** (2005) Block E. W. et al. Feedstuffs 77:20–25. http://www.ahdairy.com/uploads/articles/Feedstuffs_CSLA_72505_pg_20.pdf
- **Crushed Sunflower, Flax, or Canola Seeds in Lactating Dairy Cow Diets: Effects on Methane Production, Rumen Fermentation, and Milk Production** (2009) Beauchemin, K. A. et al. http://dx.doi.org/10.3168/jds.2008-1903
- **Feeding for Milk Components** (2012) Lock, A. L. et al. http://www.wcds.ca/proc/2012/Manuscripts/Lock.pdf
- **Invited Review: Enteric Methane in Dairy Cattle Production: Quantifying the Opportunities and Impact of Reducing Emissions** (2014) Knapp, J. R. et al. http://dx.doi.org/10.3168/jds.2013-7234
- **Methane Output and Diet Digestibility in Response to Feeding Dairy Cows Crude Linseed, Extruded Linseed, or Linseed Oil** (2008) Martin, C. et al. http://doi.dx.org/10.2527/jas.2007-0774
- **Net Energy for Lactation of Calcium Salts of Long-Chain Fatty Acids for Cows Fed Silage-Based Diets** (1991) Andrew S. M. et al. Journal of Dairy Science 74:2588–2600. http://dx.doi.org/10.3168/jds.S0022-0302(91)78437-3
- **Supplementation with Whole Cottonseed Causes Long-Term Reduction of Methane Emissions From Lactating Dairy Cows Offered a Forage and Cereal Grain Diet** (2010) Grainger, C. et al. http://dx.doi.org/10.3168/jds.2009-2888
- **The Benefits and Limitations of Fat in Dairy Rations** (1998) Jenkins, T. C. http://txanc.org/wp-content/uploads/2011/08/benefits.pdf
- **The Value of Different Fat Supplements as Sources of Digestible Energy for Lactating Dairy Cows** (2011) Weiss, W. et al. http://dx.doi.org/http://dx.doi.org/10.3168/jds.2010-3745

3.4 By-product Feeds

By-products of the food and biofuel industries can supply a large portion of the carbohydrate, protein and lipid needed by the dairy cow. By-product feeds include the rest of the plant remaining after the human edible portion is removed. In the case of biofuels, the remaining low-energy but high-protein portion of the plant remains after ethanol distillation (i.e., distillers grains).

Common examples of crop by-products include the solids that remain after processing grain, soy, potatoes, fruits, and sugarcane (e.g., stems, leaves, skins, pulp, etc.).

By-products are generally a less expensive feed than whole grains. Also, high-fiber by-products can partially serve as a substitute for forages in the diet.

3.4 By-product Feeds

Considerations

- Consider use of any available, economical by-product feeds with known nutrient composition and digestibility characteristics
- Consider using sources of highly fermentable fiber to partially replace both starch and less digestible NDF for improving rumen health and DMI
- Disadvantages of by-product feeds may include additional time needed to purchase and evaluate by-product feeds as well as the possible need for specialized storage structures
- Regular nutrient analysis of by-product feeds and corresponding ration adjustments are essential for optimum performance
- Utilize an advanced nutrition model to determine the most beneficial amount of a by-product feed to include in the diet

Resources

- **By-product feedstuffs in dairy cattle diets in the Upper Midwest** (2008) Shaver, R. http://www.uwex.edu/ces/dairynutrition/documents/byproductfeedsrevised2008.pdf
- **By-products and regionally available alternative feedstuffs for dairy cattle** (2012) Schroeder, J.W. http://www.ag.ndsu.edu/pubs/ansci/dairy/as1180.pdf
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- **Formulating dairy rations with non-forage fiber sources: Where to begin?** (2011) Bradford, B. et al. http://ecommons.library.cornell.edu/bitstream/1813/37187/2/All%20Proceedings.web.pdf
- **Using By-Product Feeds** (2010) Bernard, J. http://www.caes.uga.edu/applications/publications/files/pdf/B%201320_2.pdf
- **Utilization of By-Products from Human Food Production as Feedstuffs for Dairy Cattle and Relationship to Greenhouse Gas Emissions and Environmental Efficiency** (2012) Russomanno, K.L. et al. http://ansci.cornell.edu/pdfs/cnc2012_VAmburgh.txt.pdf
- **Value of Distillers' Grains for Lactating Dairy Cows** (2006) Donkin, S.S. et al. https://www.extension.purdue.edu/extmedia/ID/ID-334-W.pdf

3.5 Feed Additives

Feed additives are a category of ingredients fed at low inclusion rates (from milligrams to a few hundred grams a day) to improve dairy cow performance through a variety of mechanisms. Some feed additives provide specific micronutrients such as the water soluble vitamins biotin (vitamin B7) and niacin (vitamin B3) or the protected amino acids.

Most feed additives, however, are not fed in significant amounts to supply nutrients required by dairy cattle. For the most part, feed additives indirectly improve animal performance (i.e., improved health, growth or milk yield) by enhancing metabolic functions leading to improved digestive function, nutrient mobilization, acid-base balance, immune response and more.

The list of feed additives for dairy includes, but is not limited to: anionic salts, protected amino acids, *Aspergillus oryzae* products, biotin, beta-carotene, calcium propionate, protected choline, direct-fed microbials, enzymes, magnesium oxide, methionine hydroxyl analogs, monensin, niacin, propylene glycol, sodium bentonite, sodium bicarbonate, yeast products, yucca extract and zinc methionine. The long list of feed additives and various modes of action involved requires an individual evaluation for each to be included in dairy cattle diets.

A wide variety of feed additives also have been examined for their ability to inhibit methane formation in the rumen directly or indirectly. Most of these compounds have not yet produced long-term reduction of enteric methane emissions without negatively affecting milk production or being potentially toxic for the animals (e.g., nitrates). For these reasons, feed additives present moderate mitigating effects for enteric methane per unit of milk produced primarily through improved performance and health.

3.5 Feed Additives

Considerations

- Carefully evaluate available research data on each feed additive for mode of action and ability to predict positive response in your feeding conditions
- Consider evaluating feed additives according to the system proposed by Michael Hutjens, University of Illinois at Urbana-Champaign that includes: anticipated response, economic return, available research, field response, reliability, repeatability and relativity
- Consider feed additives and their expected return on investment for increasing milk production and farm profitability while reducing methane emissions
- Evaluate feed additive responses observed in a wide range of diets and consider the impact of your specific management and dietary factors

Resources

- **A Meta-Analysis of the Impact of Monensin in Lactating Dairy Cattle. Part 2 Production Effects** (2008) Duffield, T. F. et al. http://dx.doi.org/10.3168/jds.2007-0608
- **Feed Additives for Dairy Cattle** (2011) Hutjens, M. F. http://www.extension.org/pages/11774/feed-additives-for-dairy-cattle
- **Feed Additives — The Good, the Bad, and the Useless** (2007) Hutjens, M. F. http://www.wcds.ca/proc/2007/Manuscripts/Mike2.pdf
- **Long-Term Effects of Feeding Monensin on Methane Production in Lactating Dairy Cows** (2007) Odongo, N. E. et al. http://doi.dx.org/10.3168/jds.2006-708
- **Special Topics — Mitigation of Methane and Nitrous Oxide Emissions from Animal Operations: I. A Review of Enteric Methane Mitigation Options** (2013) Hristov, A. N. et al. http://dx.doi.org/10.2527/jas.2013-6583

Chapter 4: Calf and Heifer Management

Chapter Content

4.1 Colostrum
4.2 Diarrhea Prevention and Treatment
4.3 Respiratory Disease Prevention
4.4 Vaccinations
4.5 Calf Nutrition
4.6 Heifer Nutrition
4.7 Heifer Reproduction

Introduction

The main objective of calf and heifer management is to raise them in an efficient and timely manner to be healthy and productive dairy cows. As a practice, recordkeeping to monitor growth and target age-at-first calving is essential to mitigating future enteric methane in adult animals.

A heifer calf will consume feed and produce enteric methane as it grows. The economic and environmental cost of raising calves and heifers can only be offset after the bred heifer successfully calves and begins lactating; therefore, calf and heifer health, growth rate and reproductive ability are vital to profitability and minimize the carbon footprint in all dairy herds.

Calf and heifer management programs must focus on numerous factors that affect the animal's ability to stay healthy, grow and reproduce as it matures. To ensure immunoglobulin absorption for passive immunity, calves must be fed an adequate amount of high-quality colostrum within the first 24 hours of life. Clean and stress-free environments — along with appropriate vaccinations administered to the calf's dam before calving and then to the calf and heifers — are best-suited for disease prevention.

Providing required energy and protein for growth of the calf, young heifer and bred heifer is essential for timely growth in the form of muscle and bone. Keeping good records on growth, health and breeding helps evaluate and improve calf and heifer management programs.

4.1 Colostrum

Colostrum management affords a once-in-a-lifetime opportunity for a calf to become a productive and profitable member of the herd. The race to claim the passive immunity provided by immunoglobulins present in colostrum starts at birth and ends at 24 hours of life. This is due to the rapid decline in the efficiency of immunoglobulin absorption in the calf's gastrointestinal tract within hours after birth. Immunoglobulins provide passive immunity to fight disease until the calf's own immune system is developed. Failure of passive transfer (FPT) has been defined as blood serum concentrations of *immunoglobulin G* (IgG) less than 10 mg/ml at 24 hours of age. Timely feeding of an appropriate amount of high-quality colostrum (> 50 mg of IgG/ml) results in improved immunological protection, rapid early growth and higher milk production during the first lactation.

4.1 Colostrum

Considerations

- Calves should receive 4 to 5 quarts of colostrum (3 to 4 quarts for smaller dairy breeds) from a cow's first milking in one or two feedings within the first 8 hours of life
- Consider storing high-quality colostrum by refrigeration (for 24 to 48 hours) or freezing (pay careful attention to the thawing method before use). Using pasteurized colostrum will increase IgG transfer to the calf by 25 percent and is highly recommended to improve calf health
- Feed clean, high-quality colostrum from vaccinated, disease-free cows or consider pasteurized colostrum if high quality maternal colostrum is not available or if the dam or herd is known to carry disease
- Separate the calf from the dam and move to a clean and dry area to reduce disease transmission and ensure adequate colostrum intake

Resources

- **A Guide to Colostrum and Colostrum Management for Dairy Calves** (2001) BAMN http://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/bamn/BAMN01_Colostrum.pdf
- **Colostrum Management Tools: Hydrometers and Refractometers** (2011) Heinrichs, A. J. et al. http://extension.psu.edu/animals/dairy/nutrition/calves/colostrum/das-11-174
- **Heifer Raising — Birth to Weaning: Importance of Colostrum Feeding** Wattiaux, M. A. http://babcock.wisc.edu/sites/default/files/de/en/de_28.en.pdf
- **Herd-Based Problem Solving: Failure of Passive Transfer** (2010) McGuirk, S. http://www.vetmed.wisc.edu/dms/fapm/fapmtools/8calf/calf_herd_FPT_Troubleshooting.pdf
- **Managing the Young Calf – Keep It Simple!** McGuirk, S. http://www.vetmed.wisc.edu/dms/fapm/fapmtools/8calf/calfmanag.pdf
- **Nutrition Factors Causing Low Colostrum Production** (2009) Litherland, N. http://www1.extension.umn.edu/dairy/transition-cows/nutrition-factors-causing-low-colostrum-production/

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4.1 Colostrum

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- **Pasteurizing Milk and Colostrum** (2011) Godden, S. http://www.extension.org/pages/21323/pasteurizing-milk-and-colostrum#Choosing_a_liquid_feeding_program:_whole_milk_or_commercial_milk_replacer.3F
- **The Role of Oral Immunoglobulin in Systemic and Intestinal Immunity of Neonatal Calves** Quigley, J. http://www1.extension.umn.edu/dairy/beef/the-role-of-oral-immunoglobulins.pdf

4.2 Diarrhea Prevention and Treatment

Newborn calves are susceptible to neonatal calf diarrhea (calf scours), especially during their first 28 days of life. Acquired immunity from colostrum is the first and most important control measure for diarrhea.

A clean environment will help limit the influence of infectious agents (bacteria, viruses and protozoa) on calf growth. Steps should be taken to limit calves' ingestion of manure and the infectious agents it may carry. Stress weakens the immune system, so avoiding stress is important for disease prevention. Stress can result from frequent housing and feeding changes, exposure to extreme temperatures or inadequate ventilation, and lack of water availability at any time.

Early recognition of diarrhea and aggressive fluid therapy are essential to its successful treatment. Consulting with the veterinarian to identify the infectious agents involved and the appropriate antibiotic treatment is also critical for successful diarrhea treatment **(see Figure 3).**

Infectious Agent	Transmission	Age	Duration	Treatment	Prevention
E. coli (Bacteria)	Fecal/Oral Fecal/ Naval	1 - 3 days	24 hours - death	Fluid support	Good colostrum management; vaccinate dry cows
Salmonella (Bacteria - zoonotic)	Fecal/Oral Milk Nasal/Saliva In Utero	5 - 14 days	1 - 2 weeks	Antibiotics if systemic; direct sunlight will kill the organism	Pasteurize waste milk
Rotavirus (Virus)	Fecal/Oral	1 - 30 days (3-7) usually	Short but intestinal recovery is necessary	Fluid support	Colostrum from vaccinated dams will protect for 4 days
Coronavirus (Virus)	Fecal/Oral	1 - 30 days (3-7) usually	Until intestinal recovery	Fluid support	Colostrum from vaccinated dams will protect for 4 days
Cryptosporidium (Protozoa - zoonotic)	Fecal/Oral	3 - 21 days	Parasite must run its course; high fatality rates if not caught early	Fluid support	Good colostral immunity, low stress, cleanliness
Coccidiosis - Eimeria (Protozoa)	Fecal/Oral	7 days and 4 - 6 months (weaning)	Life cycle is 21 days before signs of infection are exhibited	Difficult to treat; stunts growth; lowers resistance	Starter with *coccidiostat*; pre-weaning preventive treatment

Figure 3: Common infectious agents causing diarrhea in young dairy calves

4.2 Diarrhea Prevention and Treatment

Considerations

- Colostrum feeding is essential for diarrhea prevention (see 4.1 Colostrum)
- Conduct laboratory tests and consult your veterinarian to determine what infectious agents are involved and chose antibiotics accordingly
- Provide clean and plentiful water at all times
- Reduce environmental stress and provide consistent comfort for the calf
- Replace lost body fluids with an electrolyte solution when fecal scores reaches a 2 and continue providing milk or milk replacer
- Use antibiotics if the calf has a fever (> 103°F), looks dull, is off feed, drinks slowly, has swollen navel or joints, has > 36 respirations per minute or has heart rate < 100 beats per minute
- Use fecal scores to evaluate calf manure, identify the onset of diarrhea early and determine if intervention is needed

Resources

- **Calf Diseases and Prevention** (2011) McGuirk, S. M. et al. http://www.extension.org/pages/15695/calf-diseases-and-prevention#.U6Bq-HkU9jo
- **Calf Management — Dairy Calf and Heifer Management** UW-Extension University of Wisconsin Cooperative Extension. http://www.uwex.edu/ces/heifermgmt/links.cfm
- **Calf Note 21–Feeding Scouring Calves** (2001) Quigley, J. http://www.calfnotes.com/pdffiles/CN021.pdf
- **Calf Note 43–Electrolytes For Scouring Calves** (2001) Quigley, J. http://www.calfnotes.com/pdffiles/CN043.pdf
- **CalfTrack — Calf Training Management System** (2006) Heinrichs, A. J. http://extension.psu.edu/animals/dairy/nutrition/calves/calftrack/chore-plans-in-english
- **Calves — Clinical Information and Forms, Food Animal Production Medicine** University of Wisconsin - School of Veterinary Medicine. http://www.vetmed.wisc.edu/dms/fapm/fapmtools/calves.htm
- **DCHA Gold Standards I: Production Standards for Holstein Calves, from Birth to 6 Months of Age, Across the United States** DCHA http://www.calfandheifer.org/?page=GoldStandards
- **DHCA Gold Standards III: Animal Welfare Standards for Rearing Dairy Calves and Heifers, from Birth to Freshening, Across the United States** DHCA http://www.calfandheifer.org/?page=GoldStandardsIII
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- **Sick Calf Protocols** McGuirk, S. M. http://www.vetmed.wisc.edu/dms/fapm/fapmtools/8calf/calf_protocols_ver4.pdf

4.3 Respiratory Disease Prevention

Bovine respiratory disease (BRD) describes a variety of respiratory conditions that affect the upper or lower respiratory tract. It is also commonly referred to as bronchitis, pneumonia and shipping fever.

The causative agents for BRD can be both viral and bacterial, with stress contributing to the onset of disease. Respiratory disease is prevalent and can be economically devastating because calves with BRD rarely lead healthy and productive lives even when they survive the disease.

Because treatment with antibiotics frequently fails to achieve desired results, preventive action is imperative. Factors that contribute to development of BDR include lack of proper immune transfer from colostrum, too much time spent with adult cattle and improper ventilation.

Protecting calves from environmental stress is very important for BRD prevention. Improper ventilation above the bedding (calf level) is associated with BRD. Bedding that allows the calf's legs to be completely covered is most effective in protecting the calf from drafts and chills.

Feeding large amounts of milk or milk replacer requires more bedding and attention to detail to prevent respiratory disease. Increased urine and ammonia result from high protein intakes.

4.3 Respiratory Disease Prevention

Considerations

- Colostrum feeding is essential for BRD prevention
- Control stresses associated with feeding and handling
- Consult with your veterinarian to implement an appropriate vaccination program that targets both viral and bacterial pathogens
- Consult with your veterinarian to treat affected animals with appropriate antibiotics
- House calves away from adult cattle
- Move calves to a clean and dry area within the first 30 minutes of life
- Provide deep and loose bedding that allows calves to nest and stay warm during cold weather
- Provide good ventilation consider increasing space per calf (30 to 50 square feet/calf), reducing the number of solid panels surrounding the pen and installing supplemental, mechanical positive-pressure ventilation

4.3 Respiratory Disease Prevention

Resources

- **Calf Diseases and Prevention** (2011) McGuirk, S. M. et al. http://www.extension.org/pages/15695/calf-diseases-and-prevention#.U6Bq-HkU9jo
- **Calf Respiratory Disease and Pen Microenvironments in Naturally Ventilated Calf Barns in Winter** (2006) Lago, A. et al. http://dx.doi.org/10.3168/jds.S0022-0302(06)72445-6
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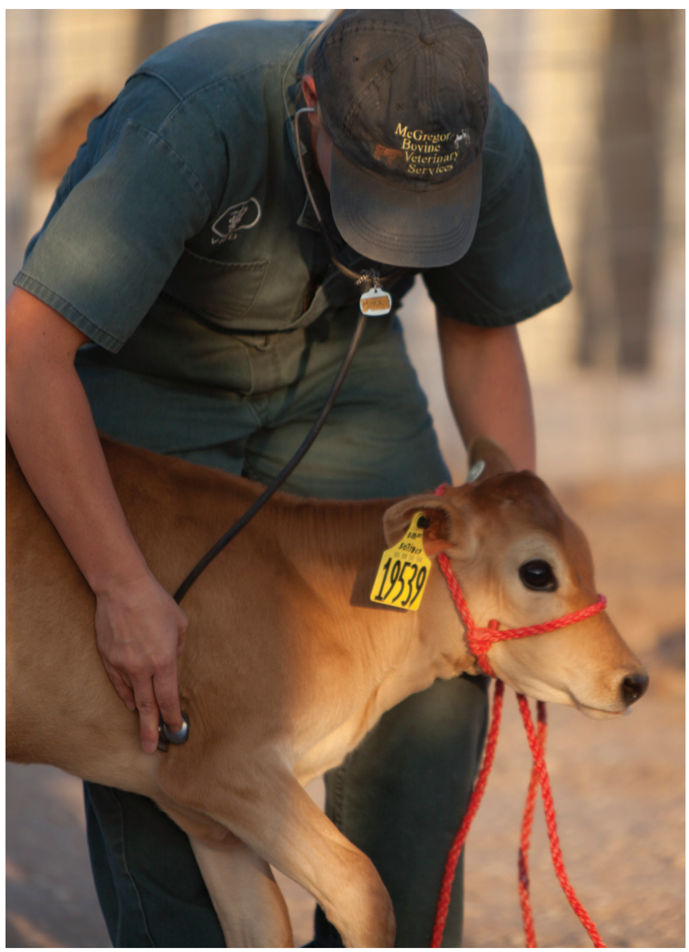
4.4 Vaccinations

In the future, specific vaccines may help to directly reduce enteric methane emissions. Currently, vaccination programs play an important role in keeping animals healthy, especially when exposed to environmental stress.

Vaccination programs make economic sense because prevention is almost always less expensive than treatment. Vaccinations also contribute to decreasing the intensity of enteric methane emissions by reducing morbidity and improving growth. Vaccination programs for each farm must be developed with a veterinarian.

Recordkeeping can reveal patterns in disease occurrence and the most-effective past vaccination strategies. Differences exist between modified live vaccines, killed (inactivated) vaccines and genetically engineered vaccines, which must be considered when developing any vaccination program.



4.4 Vaccinations

Considerations

- Consult your veterinarian to develop a custom-designed vaccination program for your farm
- Follow vaccine label directions and administer recommended boosters at the directed times
- Keep good records to reveal patterns in disease occurrence from year to year that may be associated with specific stress factors
- Time vaccinations to give the most-effective coverage before stress periods
- Understand differences between modified live vaccines, killed (inactivated) vaccines and genetically engineered vaccines and use each where appropriate
- Vaccinate healthy animals

Resources

- **Calf Diseases and Prevention** (2011) McGuirk, S. M. et al. http://www.extension.org/pages/15695/calf-diseases-and-prevention#.U6Bq-HkU9jo
- **CalfTrack — Calf Training Management System** (2006) Heinrichs, A. J. http://extension.psu.edu/animals/dairy/nutrition/calves/calftrack/chore-plans-in-english
- **DHCA Gold Standards III: Animal Welfare Standards for Rearing Dairy Calves and Heifers, from Birth to Freshening, Across the United States** DHCA http://www.calfandheifer.org/?page=GoldStandardsIII

4.5 Calf Nutrition

The goal with calf nutrition is to promote healthy, efficient, rapid growth with milk or milk replacer and enhance rumen growth and function by initiating grain intake. Conventionally, calves are fed a 20 percent CP milk replacer at a rate of 1 to 1.25 percent body weight (BW) per day or four quarts of milk per day. Data show that slightly higher amounts will help early calf growth as long as the levels of milk replacer are reduced at three weeks of age to promote grain eating.

Diet and age are the two primary factors that convert the calf's biology, a characteristic of an animal with a properly functioning rumen. By eight weeks of age, calves must have a well-developed rumen that produces high-quality rumen microbial bacteria and volatile fatty acids (to use as glucose precursors). Intake of calf starter has a causal relationship with ruminal tissue development and rumen function. An adequate freshwater supply also helps drive feed consumption and rumen development.

Field studies by Pennsylvania State University show that total DMI at weaning has a significant and positive effect on several production parameters including first lactation milk production; therefore, promoting total (milk, grain and possibly forage) intake at weaning is of paramount importance.

4.5 Calf Nutrition

Considerations

- Consider weaning calves by reducing milk feeding to one-half when they are consuming at least 3 lbs./day of starter and weaning when they are consuming at least 5 lbs./day of starter (the slow reduction in milk intake helps reduce the stress of weaning)
- Feed appropriate amounts of pasteurized milk or milk replacer
- Limit free-choice forage feeding until grain intake is adequate
- Offer clean, fresh, free-choice water
- Start introducing small amounts of fresh, palatable, high-quality starter on day 3 and increase the amount offered as the calf consumes more over time
- Transition weaned calves with as little dietary and handling stress as possible

Resources

- **A Guide to Calf Milk Replacers — Types, Use and Quality** (2008) BAMN http://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/bamn/BAMN08_GuideMilkRepl.pdf
- **A Guide to Dairy Calf Feeding and Management** (2003) BAMN http://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/bamn/BAMN03_GuideFeeding.pdf
- **A Prospective Study of Calf Factors Affecting First-Lactation and Lifetime Milk Production and Age of Cows when Removed from the Herd** (2011) Heinrichs, A. J. et al. http://dx.doi.org/10.3168/jds.2010-3170
- **Calves — Dairy Cattle Nutrition** Penn State Extension. http://extension.psu.edu/animals/dairy/nutrition/calves
- **Calf Management — Dairy Calf and Heifer Management** UW-Extension University of Wisconsin Cooperative Extension. http://www.uwex.edu/ces/heifermgmt/links.cfm
- **CalfTrack — Calf Training Management System** (2006) Heinrichs, A. J. http://extension.psu.edu/animals/dairy/nutrition/calves/calftrack/chore-plans-in-english
- **Cost-Benefit of Accelerated Liquid Feeding Program for Dairy Calves** Cabrera, V. et al. http://www.uwex.edu/ces/dairymgt/tools/documents/Accelerated.pdf
- **DCHA Gold Standards I: Production Standards for Holstein Calves, from Birth to 6 Months of Age, Across the United States** DCHA http://www.calfandheifer.org/?page=GoldStandards
- **Effect of Different Forage Sources on Performance and Feeding Behavior of Holstein Calves** (2012) Castells, L. et al. http://dx.doi.org/10.3168/jds.2011-4405
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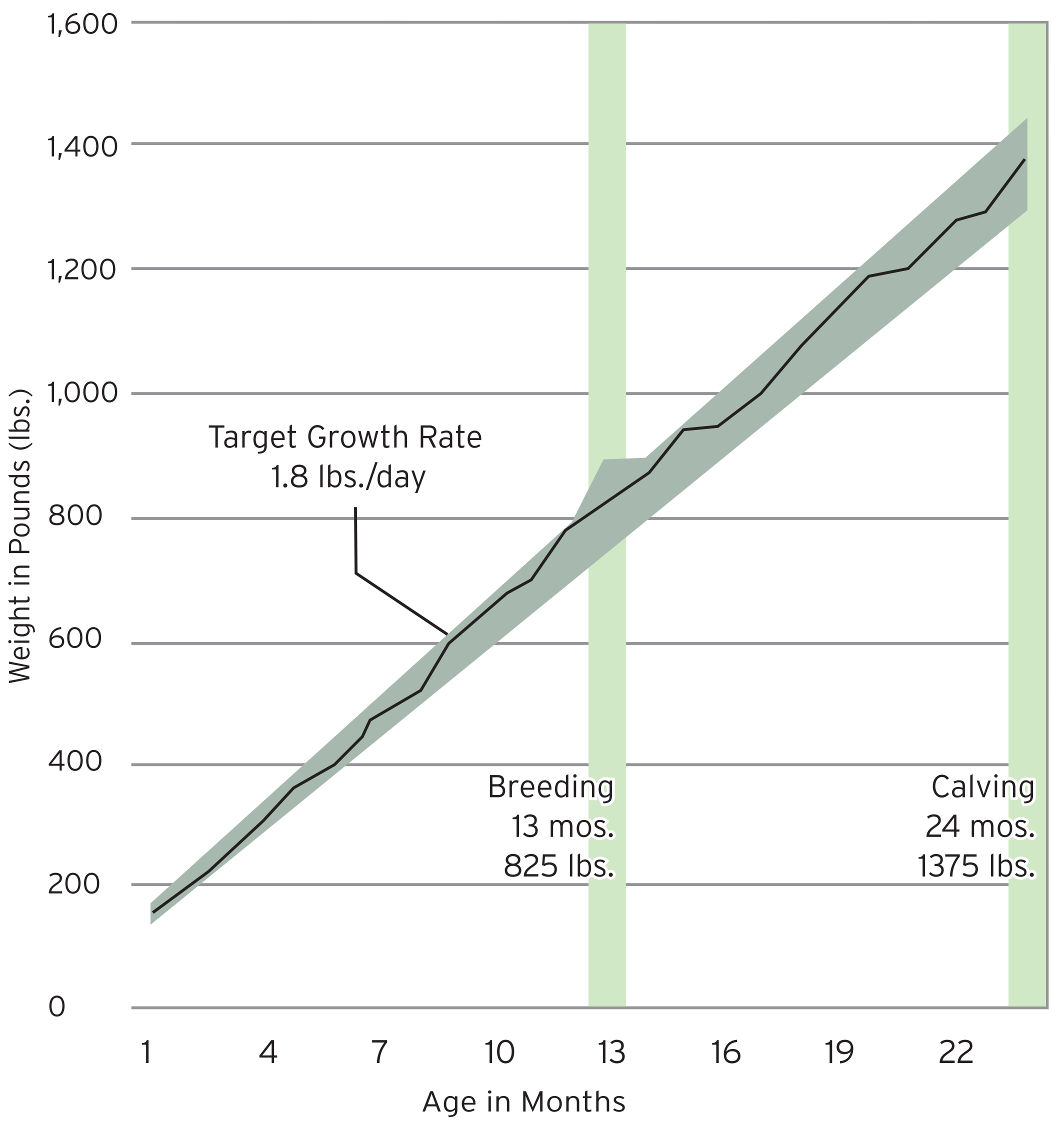
- **Review of Recent Research Investigating Effects of Calf Feeding Program on First Lactation Performance** (2011) Heinrichs, A. J. et al. http://extension.psu.edu/animals/dairy/nutrition/calves/feeding/das-11-172

4.6 Heifer Nutrition

A successful heifer raising program targets an appropriate growth rate, monitors growth and manages outliers. As average daily gain (ADG) increases, age of puberty and first calving decreases. A properly conditioned heifer that is younger than her herd mates will show increased production per year of life, longevity and good health.

The emphasis of heifer nutritional management ought to be on achieving 55 percent of projected adult weight at the time of breeding and 85 percent of projected adult weight at first calving. It is best to group heifers by size with rations that are specially formulated for each. This type of grouping will ensure that all animals receive the nutrients they need for growth without providing any excess. **(see Figure 4)**

Optimum growth from weaning to breeding is just as important as optimum growth from birth to weaning. Heifers from weaning to breeding age are capable of manufacturing sufficient quantities of high-quality ruminal microbial protein to meet their growth requirements. Postpubertal heifers have a lower protein requirement because their intakes increase and their muscle accretion grows at a lower rate than before puberty.



Target Weight (lbs.) Holstein Heifers

Month	Low	Avg.	High
1	120	130	158
2	164	175	206
3	216	220	262
4	266	275	319
5	318	335	376
6	368	410	432
7	417	475	491
8	466	520	547
9	518	600	606
10	567	655	663
11	618	705	720
12	668	775	775
13	720	825	883
14	771	870	889
15	823	940	945
16	874	950	999
17	926	990	1055
18	978	1070	1111
19	1032	1130	1166
20	1083	1185	1220
21	1135	1210	1276
22	1188	1265	1331
23	1242	1300	1385
24	1294	1375	1439

Figure 4: Example for Holstein replacement heifer target weights between 1 and 24 months of age adapded from: Nutrition and Environment - Improving Heifer Growth. (n.d.) Hoffman, P. University of Wisconsin Cooperative Extension. Retreived from http://www.uwex.edu/ces/heifermgmt.documents/papers/improvinggrowth.pdf

4.6 Heifer Nutrition

Considerations

- Adjust dietary nutrient density to changing environmental conditions
- Avoid supplying excess protein and minerals, which are excreted and contribute to the environmental impact without offering growth benefits from young calf through older heifer stages
- Control dietary nutrient delivery by providing needed nutrients according to weight class
- Manage outliers by adjusting grouping and diets for unthrifty and overconditioned heifers
- Monitor disease and consider culling unthrifty heifers with severe cases of respiratory disease or chronic conditions
- Monitor weight and height of growing animals using scales or weigh tape and measuring stick
- Target a specific growth rate to attain appropriate age at first calving goals and maximize first lactation milk yield

Resources

- **DCHA Gold Standards II: Production Standards for Holstein Heifers from 6 Months of Age to Freshening, Across the United States** DHCA http://www.calfandheifer.org/?page=GoldStandardsII
- **Effect of Nutrition and Management of Dairy Heifers on Resultant Cow Longevity** (2005) Chester-Jones, H. et al. http://www1.extension.umn.edu/dairy/calves-and-heifers/effect-of-nutrition-and-management-on-longevity.pdf
- **Feeding Strategies for Post-Weaned Dairy Heifers, 2 to 6 Months of Age** (2011) Broadwater, N. et al. http://www.extension.org/pages/11779/feeding-strategies-for-post-weaned-dairy-heifers-2-to-6-months-of-age
- **Freshening the First Calf Heifer: What the Research Shows** (2009) Litherland, N. http://www.extension.umn.edu/agriculture/dairy/transition-cows/freshening-the-first-calf-heifer/more.html
- **Heifer Management — Dairy Calf and Heifer Management UW-Extension.** University of Wisconsin Cooperative Extension. http://www.uwex.edu/ces/heifermgmt/papers.cfm
- **Nutrition and Environment — Improving Heifer Growth** (n.d.) Hoffman, P. http://www.uwex.edu/ces/heifermgmt/documents/papers/improvingrrowth.pdf
- **Novel Nutrition for Dairy Replacement Heifers** (2008) Hoffman, P. et al. http://www.uwex.edu/ces/dairynutrition/documents/2008dubuqueconferenceproceedings.pdf#page=71
- **Quality Control Systems in Dairy Replacement Heifer Nutrition. Quality Control Systems in Dairy Replacement Heifer Nutrition** (2005) Hoffman, P. http://www.uwex.edu/ces/heifermgmt/documents/papers/nutrition.pdf
- **Replacement Heifer Management Evaluation Snapshot Worksheet. Replacement Heifer Management Evaluation Snapshot Worksheet** (2007) Conway, J. et al. https://dspace.library.cornell.edu/bitstream/1813/36915/1/heifermgtsnapshot.pdf

4.7 Heifer Reproduction

Heifer reproduction programs ideally maximize profitability by maintaining or accelerating genetic progress and target a calving age of 22 to 23 months. Reducing the number of replacements needed by getting bred heifers to calve earlier is beneficial in the mitigation of enteric methane because it minimizes unproductive time.

The keys to reaching a breeding age sooner (and having an earlier first calving) are:

1. improve the heifer's nutritional status during the first year of age
2. use a sound breeding program including heat detection and artificial insemination

4.7 Heifer Reproduction

Considerations

- Consider using a tool or calculator to help you determine the cost of raising heifers on your farm
- Consider using genomics to select potentially elite heifers
- Evaluate farm records, determine current age at first calving and other heifer reproduction parameters, and compare to reasonable goals
- To improve reproductive success, consider tail chalking, estrus detection patches, pedometers, a synchronization program and ultrasound imaging for early diagnosis of pregnancy

Resources

- **Dairy Reproduction Protocols** Dairy Cattle Reproduction Council. http://www.dcrcouncil.org/protocols.aspx
- **DCHA Gold Standards II: Production Standards for Holstein Heifers from 6 Months of Age to Freshening, Across the United States** DHCA http://www.calfandheifer.org/?page=GoldStandardsII
- **Improving Dairy Heifer Reproductive Management** (2011) Graves, W. http://www.caes.uga.edu/applications/publications/files/pdf/B%201235_3.PDF
- **Methods for Managing Replacement Heifer Reproduction** (n.d.) DCRC http://www.dcrcouncil.org/media/Public/Methods%20for%20Managing%20Replacement%20Heifer%20Reproduction.pdf
- **New Tools of Management of Dairy Heifers** (2003) Fricke, P. M. et al. http://babcock.wisc.edu/sites/default/files/documents/productdownload/du_608.en_.pdf
- **Strategies for Optimizing Reproductive Management of Dairy Heifers** (2004) Fricke, P. M. http://www.wcds.ca/proc/2004/Manuscripts/163Fricke.pdf

Chapter 5: Transition Cow Nutrition and Management

Chapter Content

5.1 Prepartum Cow Nutrition and Management
5.2 Postpartum Nutrition and Management
5.3 Transition Cow Comfort
5.4 Use of Technology for Cow Management

Introduction

During the transition period, cows experience more stress. Effective cow management during transition will not only reduce involuntary culling, replacement costs and non-productive days, but it will increase milk yield in the following lactation, allow for a lifetime of productivity and reduce enteric methane emissions per unit of fat- and -protein-corrected milk production.

Both physical and metabolic stresses occur as cows transition from milking to the dry period, through calving and into the following lactation. Proper nutrition and management of cows at each transition are essential in helping them to adjust to rapid and dramatic changes in physiology and nutrient requirements. Actions taken during transition significantly influence subsequent milk yield, lactation length, incidence of disease and reproductive efficiency, therefore directly affecting herd composition and profitability, and indirectly influencing enteric methane emissions. Management goals include: 1) preparation for a successful calving and subsequent lactation by promoting cow comfort and DMI 2) meeting, but not exceeding, transition cow nutritional requirements; and 3) reducing the incidence of postpartum metabolic diseases.

5.1 Prepartum Cow Nutrition and Management

A successful lactation starts long before calving. A dry period between 45 and 65 days is necessary for replacement and repair of mammary epithelial cells and for some rejuvenation of the rumen. Energy-limited diets that are higher in forage content and encourage greater intakes as calving nears promote subsequent milk yield and help

to prevent physiological and infectious diseases postpartum.

Rations fed to dry cows should provide an amount of MP and amino acids as close as possible to the requirements of the dry cow and unborn calf. High milk production and low frequency of health problems can be achieved by feeding far-off (-60 to -21 days in milk) and close-up (-21 to 0 days in milk) rations or a single dry cow ration. Grouping heifers separately can help prevent stress-related postpartum
health problems.

Proper mineral and vitamin nutrition is critical for dry cows. Any deficiencies in vitamins E and A, selenium, copper or zinc will weaken the immune response. Vitamin E and selenium help reduce the incidence of retained placentas and mastitis.

A cation-anion imbalance can cause clinical or subclinical milk fever, reduced feed intake and rumen function, greater body fat mobilization, and increased risk for a displaced abomasum. Also, cation-anion imbalances can reduce teat sphincter muscle contractions, allowing entrance of mastitis-causing microorganisms. Using forages low in potassium can help to control the dietary cation-anion balance, and dietary supplementation with anionic salt mixtures (greater concentrations of chloride and sulfate) may be necessary in close-up diets.

Photo provided by Midwest Dairy Association

5.1 Prepartum Cow Nutrition and Management

Considerations

- Adjust dietary energy density during late lactation and the dry period according to body condition score (BCS)
- Consider well-researched feed additives that improve rumen function, increase DMI and reduce subclinical ketosis and fatty liver
- Determine optimum dry period length and devise a system to manage cows accordingly
- Formulate dry cow diets using a nutrition model that predicts metabolizable energy and protein, as well as amino acids supplies and requirements, paying attention not to overfeed energy
- Have fresh feed available 24 hours per day
- Maintain access to feed 24 hours a day and provide fresh feed more frequently
- Monitor BCS with the goal of maintaining cows at a score of 3.0 to 3.5 to reduce calving problems and metabolic disease
- Monitor DMI and consider ways to increase it

5.1 Prepartum Cow Nutrition and Management

Resources

- **Back to a Traditional Approach: Re-Evaluating the Use of a Single Dry Period Diet** (2011) Drackley, J. K. http://www.wcds.ca/proc/2011/Manuscripts/Drackley.pdf
- **Dairy Extension — Transition Cows** University of Minnesota Extension. http://www.extension.umn.edu/agriculture/dairy/transition-cows/
- **Feeding and Managing the Transition Dairy Cow** (2012) Schroeder, J. W. http://www.ag.ndsu.edu/pubs/ansci/dairy/as1203.pdf
- **Feeding the Dry Cow** (2011) Royón-Díaz F. et al. http://pubstorage.sdstate.edu/AgBio_Publications/articles/exex4047.pdf
- **Nutritional Management of Transition Dairy Cows: Strategies to Optimize Metabolic Health** (2004) Overton, T. R. et al. http://dx.doi.org/10.3168/jds.S0022-0302(04)70066-1
- **Optimizing Intake in Dry and Prefresh Cows** (2011) Overton, T. R. http://www.wdmc.org/2011/Optimizing%20Intake%20in%20Dry%20and%20Prefresh%20Cows%20pg%20195-206.pdf
- **Revisiting Negative Dietary Cation-Anion Difference Balancing for Prepartum Cows and its Impact on Hypocalcaemia and Performance** (2011) Block, E. http://dairy.ifas.ufl.edu/rns/2011/5block.pdf
- **Role of Mineral and Vitamin Status on Health of Cows and Calves** (2011) Spears, J. W. http://www.wcds.ca/proc/2011/Manuscripts/Spears.pdf
- **Unique Aspects of Dairy Cattle Nutrition** (2001) In: Nutrient Requirements of Dairy Cattle, Seventh Revised Edition (pp. 184–213). http://www.nap.edu/openbook.php?record_id=9825

5.2 Postpartum Nutrition and Management

Postpartum dairy cows with high-yield potential cannot meet their energy demands from dietary intake alone. These cows depend on body reserves to balance the deficit between dietary intake and nutrient requirement increasing the risk for ketosis and other health problems.

Minimizing the severity and duration of a negative energy balance can be accomplished through balanced nutrition. A balanced ration for postpartum dairy cows should support increased plasma glucose and insulin concentrations and decreased plasma non-esterified fatty acid concentrations and liver fat content, and maintain rumen fill to avoid a displaced abomasum.

Grouping fresh cows separately for two to three weeks postpartum can help maximize DM and energy intake to more quickly return cows to a positive energy balance. The postpartum or fresh cow diet should be slightly lower in starch than the high-producing cow diet. Avoid highly fermentable starch sources, provide rumen-effective fiber to increase DMI and reduce the risk for ruminal acidosis.

5.2 Postpartum Nutrition and Management

Considerations

- Evaluate transition cow success using tools such as the Transition Cow Index™ as well as monitoring disease incidence and evaluating blood serum metabolites
- Formulate fresh cow diets using a nutrition model that predicts metabolizable energy and protein as well as amino acids supplies and requirements
- Provide access to feed 24 hours a day
- Routinely monitor DMI and consider ways to increase it
- Supply combinations of energy and protein sources that maintain rumen health
- Consider well-researched feed additives that improve rumen function, increase DMI and reduce subclinical ketosis and fatty liver

Resources

- **Body Condition Scoring** Penn State Extension. http://extension.psu.edu/animals/dairy/nutrition/nutrition-and-feeding/body-condition-scoring
- **Early Lactation Diets for Dairy Cattle–Focus on Starch** (2011) Dann, H. M. et al. http://ecommons.cornell.edu/bitstream/1813/37187/2/All%20Proceedings.web.pdf
- **Food Animal Production Medicine Clinical Information and Forms – Transition Cow and Transition Cow Index™.** University of Wisconsin - School of Veterinary Medicine. http://www.vetmed.wisc.edu/dms/fapm/fapmtools/transition_cow.htm
- **Major Advances in our Understanding of Nutritional Influences on Bovine Health** (2006) Goff, J. P. http://dx.doi.org/10.3168/jds.S0022-0302(06)72197-X
- **Meeting the Energy and Protein Challenges of Post-Fresh Transition Cows** (2012) Grummer, R. R. et al. http://txanc.org/wp-content/uploads/2012/05/4_Grummer_Meeting-the-Energy-and-Protein-Challenges_2012-MSRNC_FINAL.pdf
- **Metabolic Implications for Transition Cow Immunity** (2011) Waldron, M. R. http://www.livestocktrail.illinois.edu/uploads/dairynet/papers/3%20Waldron%2Epdf
- **Postpartum Uterine Diseases: Prevalence, Impacts, and Treatments** (2011) Dubuc, J. http://www.wcds.ca/proc/2011/Manuscripts/Dubuc.pdf
- **The Effect of Subclinical Ketosis in Early Lactation on Reproductive Performance of Postpartum Dairy Cows** (2007) Walsh, R. B. et al. http://dx.doi.org/10.3168/jds.2006-560
- **Transition Cow Index Monitors Fresh Cow Performance** (2008) Nordlund, K. http://www.ansci.cornell.edu/pdfs/pd2008febp20.pdf
- **Unique Aspects of Dairy Cattle Nutrition** (2001) In: Nutrient Requirements of Dairy Cattle, Seventh Revised Edition (pp. 184–213). http://www.nap.edu/openbook.php?record_id=9825

5.3 Transition Cow Comfort

During the transition period, cows mobilize energy from body reserves, compromising the immune system and increasing the risk for disease. Stress reduces DMI and increases fat mobilization as well as the incidence of metabolic diseases. Dry and fresh cow rations may be well-balanced, but if cows are stressed and intake is compromised, metabolic diseases are more likely to occur.

To ensure cow comfort, overcrowding, competition, stall size, bedding, time budgets, number of pen moves and heat stress must be considered. Dry cows need uninhibited access to feed so they can eat as much of a bulky ration as possible. Transition cows should be lying down approximately 14 hours per day in clean, dry, well-lit stalls or pens.

Overcrowding results in cows spending more time waiting to lay down and reduces the amount of time remaining to eat. In addition, improving cow comfort allows cows to reach their potential for milk yield.

The purposes for housing fresh cows in a separate pen for two to three weeks postpartum are to:

1. minimize social stress
2. provide a fresh cow diet
3. facilitate fresh cow monitoring by trained farm operators

Because fresh cows are less aggressive and more easily pushed away from the feed, fresh cow pens should always be kept understocked.

5.3 Transition Cow Comfort

Considerations

- Assess bedding adequacy, flooring and ventilation to determine if changes can be made to improve cow comfort
- Avoiding heat stress is particularly important for transition dairy cows
- Compare current transition-cow stocking density, feedbunk space, freestall dimensions and cow time budgets to recommendations and take steps to improve, if necessary
- Consider having a separate fresh cow group (from 0 to 14 or 21 days in milk) and separate first-calf heifers from mature cows if possible
- Consider ways to limit the number of times cows move to different pens while still providing optimum nutrition, cow comfort and handling
- Ensure access to water in the maternity pen
- Ensure trained farm operators assess fresh cow appetite, temperature, rumen motility, vaginal discharge, manure and udder appearance, and treat appropriately
- Ensure trained farm operators check dry cows from 21 days before calving up until calving day (prefresh cows) hourly, treat if necessary, and move to appropriate pen

5.3 Transition Cow Comfort

Resources

- **Cow Comfort Drives Transition Cow Success** (2011) Nordlund, K. http://www.livestocktrail.illinois.edu/uploads/dairynet/papers/18%20Nordlund%2Epdf
- **Creating the Physical Environment for Transition Cow Success** (2010) Nordlund, K. http://extension.psu.edu/animals/dairy/courses/dairy-cattle-nutrition-workshop/previous-workshops/2010/materials-from-main-sessions/penn-state-nutrition-workshop/creating-the-physical-environment-for-transition-cow-success
- **Effect of Heat Stress During the Dry Period on Mammary Gland Development** (2011) Tao, S. et al. http://dx.doi.org/10.3168/jds.2011-4329
- **Facility Designs to Maximize Transition Cow Health and Productivity** (2009) Cook, N. http://www.wcds.ca/proc/2009/Manuscripts/FacilityDesignsMaximizeTransition.pdf
- **Reducing Between-Cow Variation in Nutrient Intake Through Feed Bunk Management** (2011) DeVries, T. http://www.livestocktrail.illinois.edu/uploads/dairynet/papers/16%20DeVries%2Epdf
- **The Dairyland Initiative** University of Wisconsin - School of Veterinary Medicine. https://thedairylandinitiative.vetmed.wisc.edu/index.htm
- **Transition Cow Research – What Makes Sense Today?** (2010) Block, E. http://www.highplainsdairy.org/2010/18_Block_Transition%20CowResearch_FINAL.pdf

"... Housing constraints related to cow comfort are the major risk factors for fresh cow health in freestall dairies today."

Dr. Ken Nordlund

5.4 Use of Technology for Cow Management

Dairy cows are typically housed in groups, yet many management decisions on the dairy farm are made at the individual cow level. The use of sensors to collect data on individual cows, coupled with software that analyzes and interprets the data in real time, can improve on-farm animal management.

For example, technologies that measure a cow's production, behavior, appearance or physiology can be used for improving detection of estrus, pregnancy and onset of calving. Sensor systems can also improve diagnosis of ketosis (and other metabolic disorders), lameness or mastitis, and monitor rumination or BCS.

These systems include a variety of sensors such as pedometers, image capture systems and ruminal pH meters. New sensors will likely continue evolving rapidly. The potential benefits of these technologies are usefull to both transition and lactating cows in diagnosing, for example, either post partum metabolic disorders or determining mastitis before clinical signs are evident.

5.4 Use of Technology for Cow Management

Considerations

- Adopt technologies to support and enhance existing good management practices
- Consider animal management technology investments on an individual farm basis
- Evaluate and understand existing strengths and weaknesses in animal management before making decisions on technology investments
- Evaluate and understand the benefits and costs associated with each technology
- Leverage technologies already in use at the farm, such as dairy records software

Resources

- **Invited Review: Sensors to Support Health Management on Dairy Farms** (2013) Rutten C. J. et al. Journal of Dairy Science 96:1928-1952. http://dx.doi.org/10.3168/jds.2012-6107
- **Precision Dairy** (2013) University of Minnesota. http://precisiondairy.umn.edu/DownloadProceedings/index.htm
- **Precision Dairy Management** (2010). http://www.precisiondairy2010.com/default.htm
- **Pre-Investment Considerations for Precision Dairy Farming Technologies** (2013) Dolecheck, C., and Bewley J. University of Kentucky. Retrieved from http://www2.ca.uky.edu/agc/pubs/ASC/ASC208/ASC208.pdf
- **New Technologies in Precision Dairy Management** (2013) Bewley J. In Western Canadian Dairy Seminar Advances in Dairy Technology (pp. 141-159) http://www.wcds.ca/proc/2013/Manuscripts/p%20141%20-%20162%20Bewley.pdf

Chapter 6: Lactating Cow Management

Chapter Content

6.1 Milk Quality
6.2 Mastitis Control
6.3 Cow Comfort
6.4 Reproduction
6.5 Culling

Introduction

Lactating dairy cows produce the milk that is sold for profit to provide economic sustenance to the dairy herd. Improving the efficiency of quality, saleable milk production on the farm increases profit and reduces enteric methane emissions per unit of fat- and -protein-corrected milk. This can be achieved by optimizing milk yields and improving milk quality.

Lactating cow management must focus on: 1) preserving cow health in order to achieve high levels of milk production with high milk quality, 2) disease prevention and treatment to minimize milk loss and involuntary culling of productive animals from the herd, 3) dietary needs of early lactation when dairy cows do not yet consume enough feed to meet the large nutrient demands for milk production, and 4) physiological changes that occur in cows as lactation progresses, placing emphasis on reproductive success, pregnancy and preparation for the subsequent calving.

Opportunities begin in the milking parlor, where consistent milking procedures, routines and equipment maintenance optimize cleanliness and sanitation for the harvest of saleable milk. Mastitis prevention, identification and treatment can reduce milk wastage and losses in potential milk yield, increasing the value of a cow's productive life. Practices and facilities that improve cow comfort, cow time budgets and reproductive efficiency lead to improved milk production efficiency of the whole herd.

6.1 Milk Quality

The quality of raw milk has a significant effect on taste, odor and shelf life of fluid milk, and on yields of manufactured dairy products.

Benchmarks are already in place through government regulations. In the U.S., Grade "A" pasteurized milk for human consumption

may not exceed 750,000 somatic cell counts (SCC) and 100,000 standard plate counts (SPC) per milliliter (ml), and may not contain any antibiotic or chemical residues. In the European Union, the maximum allowable limit for SCC is 400,000 per ml.

Regulations and Incentives: Milk processors in the U.S. frequently adopt guidelines that comply with the regulations, but also target higher milk quality goals.

For example, milk quality targets of 250,000 to 200,000 SCC and 20,000 to 10,000 SPC per ml are common among dairy processors and manufacturers.

Dairy farmers must consistently apply good management practices to produce milk that meets or exceeds these quality requirements. Cow cleanliness and proper procedures at the milking parlor offer the greatest opportunity to improve milk quality.

For example, forestripping before teat-end disinfection stimulates oxytocin release and allows for detection of clinical mastitis by visual examination of milk appearance. Milk quality also is influenced by proper sampling, milk cooling and equipment hygiene and upkeep.

Farmers also have economic reasons to seek high milk quality because of gains in price premiums and improvements in individual cow milk yields.

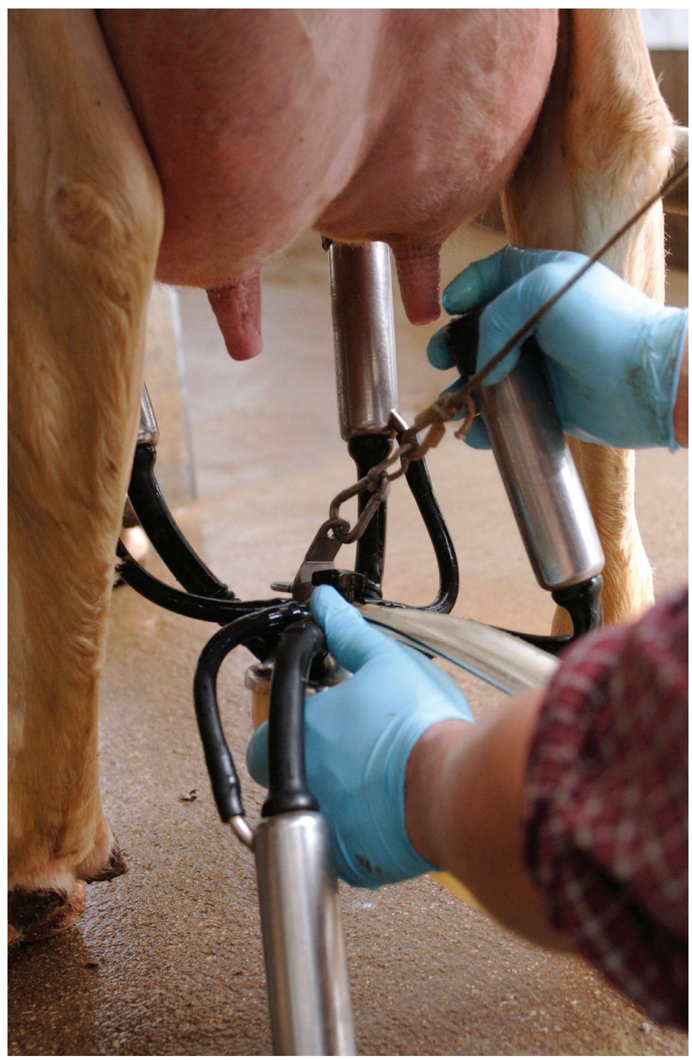
Measures of Milk Quality: Milk quality is measured by SCC, SPC, preliminary incubation (PI) counts, laboratory pasteurization counts (LPC) and coliform counts (CC). Bulk tank SCC of 200,000 cells/ml indicates a low incidence level of mastitis in the herd and higher SCC is associated with lost milk production. At least eight percent of potential milk production is lost in herds with SCC of 200,000 to 500,000 (see page 57, How Milk Quality is Assessed S.P. Oliver).

An SPC, or raw count, measures total bacteria. A low SPC can be achieved by ensuring that the milking system cleans properly, following proper milking procedures, cooling milk quickly, ensuring good udder hygiene and taking additional steps to prevent mastitis.

A PI count identifies psychrotrophic bacteria, or bacteria that survive in cold temperatures. A low PI count depends on appropriate holding temperatures and holding times for milk, adequate sanitation, well-maintained equipment, clean water supply and consistent milking practices to ensure that dry teats are being milked.

The LPC estimates the number of bacteria that can survive laboratory pasteurization at 62.8°C (143°F) for 30 minutes. It is likely that future standards will rely more heavily on LPC than they had in the past.

Finally, CC indicates the amount of manure in the milk, indicating poor milking procedures, contaminated water, dirty cows, dirty facilities or milking cows infected with coliform mastitis.



6.1 Milk Quality

Considerations

- Always remove dip with a clean towel to prevent the spread of mastitis-causing bacteria (dry teats decrease the risk for high SPC or CC)
- Evaluate milking procedures to prevent the spread of bacteria during milking
- Include forestripping before teat disinfection to stimulate milk letdown and detect abnormal milk or signs of mastitis
- Include the use of a reputable disinfectant to dip the teats or use disinfecting wipes
- Liners should be replaced after the recommended number of milkings and/or milk quality data, type of liner material and number of washes, as recommended by manufacturers
- Periodically check that the milking system is functioning properly so that teat ends are not damaged, milk out is complete and washing procedures are effective
- Use clearly defined milking procedures and trained milkers
- Disposable gloves should be used by all milkers to reduce the spread of bacteria and to protect their hands

Resources

- **Best Milking Practices Checklist** (2013) Penn State Extension. http://extension.psu.edu/animals/dairy/health/milk/best-milking-practices-checklist
- **Dairy Operators Guide to Milking Machine Cleaning and Sanitation** (2001) Reinemann D. J. In National Resource, Agriculture, and Engineering Service, Milking Systems and Parlors Conference http://milkquality.wisc.edu/wp-content/uploads/2011/10/operators-guide-to-milking-machine-cleaning-and-sanitation.pdf
- **How Milk Quality is Assessed** (2010) Oliver S. P. The University of Tennessee. http://www.extension.org/pages/21197/how-milk-quality-is-assessed
- **Milk Money** Unversity of Wisconsin-Madison. http://milkquality.wisc.edu/programs/milk-money/
- **NMC Publications** National Mastitis Council http://nmconline.org/publications.html
- **NMC Resources** National Mastitis Council http://nmconline.org/documents.html
- **Recommended Milking Procedures** National Mastitis Council. http://nmconline.org/milkprd.htm
- **Standard Operating Procedures: Managing the Human Variables** (2002) Stup R. National Mastitis Council. http://www.nmconline.org/articles/sop.pdf
- **UW Milk Quality** University of Wisconsin-Madison. http://milkquality.wisc.edu/

6.2 Mastitis Control

Mastitis is an infection of the mammary gland from bacteria, viruses or fungi entering through the teat. Dairy farmers can prevent mastitis by keeping bacteria away from the teat end and striving for conditions that support resistance by the cow against mastitis-causing bacteria.

Proper treatment depends on the distinction between contagious or environmental mastitis-causing bacteria. Contagious mastitis organisms are typically transferred from cow to cow, primarily during milking. Environmental mastitis organisms are typically associated with periods of high humidity, challenging weather conditions, mechanical actions, environmental issues and nutritional factors that affect overall immunity and udder health.

Mastitis can also be classified as clinical and subclinical. Subclinical mastitis presents no visible symptoms but accounts for the majority of total mastitis-associated costs. A culturing program suitable for each farm can provide guidance on clinical mastitis treatment decisions by determining which type of organism is responsible for the infection. Quick application of the appropriate treatment will reduce milk losses and the time needed for antibiotics.

6.2 Mastitis Control

Considerations

- Bedding must be topped or changed to keep it free of manure and organic load
- Consider dry cow therapy and mastitis vaccination to reduce mastitis at the herd level
- Consider inorganic bedding, such as sand, to decrease the organic load and bacteria counts in bedding material
- Develop a program to prevent the spread of bacteria with simple and clear steps that ensure appropriate milking procedures, clean and dry cows and employee hands, and a clean and well-maintained milking system
- If on-farm culturing is cost prohibitive, then access to on-time information may be suitable
- Improve immunity with balanced nutrition, especially focusing on providing key vitamins and minerals known to reduce mastitis
- Prevent bacteria from entering the open teat ends by pre- and postdipping, encouraging cows to stand for 30 to 60 minutes following milking by offering fresh feed and maintaining clean, well-bedded free stalls
- Reduce environmental mastitis by avoiding overstocking and maintaining bedding and manure management practices that limit the buildup of manure and moisture in the cow's living environment
- Use on-farm culturing to identify mastitis-causing organisms and make more effective decisions about clinical mastitis treatment

6.2 Mastitis Control

Resources

- **Are Your Cows Getting the Vitamins They Need?** (2006) Weiss, W., and G. Ferreira. In Western Canadian Dairy Seminar Advances in Dairy Technology (pp. 249-259) http://www.wcds.ca/proc/2006/Manuscripts/Weiss2.pdf
- **Current Status and Future Challenges in Mastitis Research** (2011) Hogeveen H. S. et al. In National Mastitis Council Annual Meeting Proceedings (pp. 36-48) http://www.nmconline.org/articles/MastitisStatus.pdf
- **Decision Tree Analysis of Treatment Strategies for Mild and Moderate Cases of Clinical Mastitis Occurring in Early Lactation** (2011) Pnizon-Sanchez C. et al. Journal of Dairy Science 94:1873-1892. http://dx.doi.org/10.3168/jds.2010-3930
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- **Milk Quality and Mastitis** University of Minnesota - Extension. http://www.extension.umn.edu/agriculture/dairy/milk-quality-and-mastitis/
- **Role of Mineral and Vitamin Status on Health of Cows and Calves** (2011) Spears, J. W. In Western Canadian Dairy Seminar Advances in Dairy Technology (pp. 287-297) http://www.wcds.ca/proc/2011/Manuscripts/Spears.pdf
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6.3 Cow Comfort

Cow comfort – a term broadly adopted by the dairy industry – is a key factor affecting cow welfare. Cow comfort refers to how the dairy cow copes with her environment. Most of the emphasis is placed on the areas available for feeding, lying and standing.

Factors normally considered when evaluating cow comfort include signs of heat stress, lameness, skin injuries and health. Facility and management factors that can affect cow comfort (and, in many cases, time budgets) include stall design; stall surface, including the amount of bedding provided; stocking density at the stall and at the feed barrier; regrouping schedules; and cow cooling and handling protocols, such as cow movement and time spent away from the pen.

Cows are herd animals. Ideally, they thrive in facilities that provide sufficient space for them to eat and lay down at the same time. Feeding and resting are related in dairy cows, and lack of rest will reduce time spent feeding and milk production.

For example, freestall facilities need to provide at least one stall per animal and ideally more than 24 inches of feed bunk space (the current industry standard) for each lactating cow.

Cows also spend some time standing idle which, ideally, would be minimized to encourage eating, resting and ruminating. It is also beneficial to minimize time spent away from the pen, such as travel time to the parlor and milking. In addition, providing cows with a dry place to stand in the pen and when they are away from the pen will dramatically improve their comfort.

6.3 Cow Comfort

Considerations

- In situations where lameness, injuries or disease rates are identified as a problem cow comfort should be evaluated by the herd manager, veterinarian, hoof trimmer, nutritionist and any other individuals involved in cow care
- Protocols for minimizing the negative affects of heat stress should be evaluated on a regular basis
- Routine lameness and injury-scoring protocols should be implemented
- Transition cow disease (and other health issues) rates should be recorded and reviewed periodically

Resources

- **Design Considerations For Dairy Cattle Free Stalls** (2010) Graves R. et al. Penn State University. http://www.extension.org/pages/11015/design-considerations-for-dairy-cattle-free-stalls
- **Effects of Cow Comfort on Milk Quality, Productivity and Behavior** (2009) Krawczel, P., and R. Grant. In National Mastitis Council Annual Meeting Proceedings (pp. 15-24) http://nmconline.org/articles/comfortSCC.pdf
- **Effect of Heat Stress During the Dry Period on Mammary Gland Development** (2011) Tao S. et al. Journal of Dairy Science 94:5976-5986. http://dx.doi.org/10.3168/jds.2011-4329
- **Effect of Lameness on Culling in Dairy Cows** (2004) Booth C. J. et al. Journal of Dairy Science 87:4115-4122. http://dx.doi.org/10.3168/jds.S0022-0302(04)73554-7
- **Economic Losses from Heat Stress by US Livestock Industries** (2003) St-Pierre N. R. et al. Journal of Dairy Science 86:E52-E77. http://dx.doi.org/10.3168/jds.S0022-0302(03)74040-5
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- **Invited Review: The Welfare of Dairy Cattle — Key Concepts and the Role of Science** (2009) von Keyserlingk M. A. G. et al. Journal of Dairy Science 92:4101-4111. http://dx.doi.org/10.3168/jds.2009-2326

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Resources

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- **Sand for Bedding Dairy Cow Stalls** (2012) Gooch, C., and S. Inglis. Cornell University. http://www.extension.org/pages/65458/sand-for-bedding-dairy-cow-stalls
- **Stocking Density and Time Budgets** (2009) Grant, R. In Western Dairy Management Conference Proceedings (pp. 7-17), Reno, NV. http://www.wdmc.org/2009/Stocking%20Density%20&%20Time%20Budgets.pdf
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- **The Feeding Behavior of Dairy Cows: Considerations to Improve Cow Welfare and Productivity** (2010) Botheras, N. The Ohio State University. http://www.extension.org/pages/25472/the-feeding-behavior-of-dairy-cows:considerations-to-improve-cow-welfare-and-productivity

Photo provided by Leandro Abdelhadi

6.4 Reproduction

A short calving interval of 40 to 60 days with more time spent in the early and mid-lactation stages will improve average milk yield per cow and reduce non-productive days and the number of replacement animals needed in the herd.

The keys to reproductive success include effectively managing the transition period (see Chapter 5), maintaining the reproductive tract free of inflammation and disease, minimizing the severity and duration of negative energy balance in early lactation, providing balanced nutrition (see Chapters 1, 2, and 3 on feed management), and implementing a reproductive management or breeding program.

6.4 Reproduction

Considerations

- Consistently monitor and evaluate artificial insemination techniques, timing and success
- Determine current conception rate, 21-day pregnancy rate, services per conception, days open, days to first service and calving interval to compare with reasonable goals and identify areas for improvement
- Evaluate herd reproductive health and estrous cyclicity at breeding time and consider strategies to reduce calving problems, metritis, clinical endometritis and fever postpartum
- Monitor body condition score as an indicator of negative energy balance in early lactation
- To improve reproductive success, consider tail chalking, estrus detection patches, pedometers, progesterone analyses, a synchronization program and ultrasound imaging for early diagnose of pregnancy

Resources

- **Dairy Cattle Reproduction** (2014) eXtension. http://www.extension.org/pages/15604/dairy-cattle-reproduction
- **Feeding n-6 and n-3 Fatty Acids to Dairy Cows: Effects on Immunity, Fertility and Lactation** (2009) Silvestre F. T. et al. In Proceedings 2009: 20th Annual Florida Ruminant Nutrition Symposium (pp. 75–90), Gainsville, Florida. http://dairy.ifas.ufl.edu/rns/2009/Silvestre.pdf
- **Invited Review: Milk Production and Reproductive Performance: Modern Interdisciplinary Insights into an Enduring Axiom** (2012) Bello N. M. et al. Journal of Dairy Science 95:5461–5475. http://dx.doi.org/10.3168/jds.2012-5564
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6.4 Reproduction

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- **Management Strategies to Improve Fertility in Lactating Dairy Cows** (2006) Fricke, P., and R. Sterry. In High Plains Dairy Conference Proceedings http://www.uwex.edu/ces/dairyrepro/documents/ConfRH.pdf
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6.5 Culling

Culling occurs when cows leave the herd due to sale to another dairy, slaughter-salvage or death. Management strategies to promote productivity and profitability should work to minimize forced culling by focusing on the areas of transition cow management, cow comfort, reproductive performance, mastitis, lameness and milk production.

Within the dairy literature, many experts advocate that lower annual herd turnover rates are more profitable and use less resources per unit of fat- and -protein corrected milk produced, with optimum turnover rates at 25 to 30 percent. Culling decisions, however, depend on many factors, and turnover rate alone does not indicate good management. Because dairy farms vary widely, ideal culling rates will also vary by farm. It is important to use systematic, data-driven performance records and determine the value of each cow individually when making culling decisions. For example, each cow's retention payoff value and culling turnover rates must meet the individual farm's economic and environmental goals.

6.5 Culling

Considerations

- Calculate individual cow profitability, whether it is more profitable to keep a cow or replace her; the answer depends on milk price, feed cost, the difference between cull and replacement values and availability of capital
- Calculate overall culling rate, number of cows leaving the heard in early lactation and cow deaths, and compare to industry benchmarks
- Determine if barn is filled to capacity before making economic culling decisions
- Evaluate reasons for culling and, if needed, take actions to improve

Resources

- **Cow Culling Decisions: Costs or Economic Opportunity?** (2007) Dhuyvetter K. C. et al. In 2007 Proceedings from the Western Dairy Management Conference (pp. 2-16) http://www.wdmc.org/2007/dhuyvetter.pdf
- **Culling Rate on Dairy Farms and Its Effect on Income Over Feed Costs and Forage Inventory Requirements** (2013) St-Pierre, N. R. In Proceedings of the 2013 Tri-State Dairy Nutrition Conference (pp. 153-159) http://tristatedairy.osu.edu/Proceedings%202013/Normand%20St-Pierre.pdf
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Abbreviations and Definitions

ADG	Average daily gain	Rate of weight gain by an animal per day
BCS	Body condition score	Five-point scale used for the evaluation of the fatness of a dairy cow. Both visual and tactile evaluation of body fat reserves are used. A score of 1 represents an emaciated or very thin cow and a score of 5 represents an excessively fat cow. A score of 3 represents average body condition
BRD	Bovine respiratory disease	General term describing a variety of respiratory conditions affecting a cow's upper or lower respiratory tract; causative agents can be both viral and bacterial, with stress contributing to the onset of disease
BW	Body weight	The weight of an animal's body
CC	Coliform counts	Estimates the number of coliform bacteria that originate from contaminated environments or manure in a milk sample. It is obtained by plating a milk sample on Violet Red Bile agar or MacConkey's agar and counting the typical coliform colonies that grow after incubation. CC is quantified as colony forming units (CFU) per ml
CP	Crude protein	Amount of true protein and non-protein nitrogen in feed that is calculated from the measurement of nitrogen content in feed multiplied by 6.25
DE	Digestible energy	Amount of energy absorbed by an animal that is calculated as the difference between the energy content in feed and feces
DIM	Days in milk	Number of days from calving date
DM	Dry matter	The part of a feedstuff that remains when all its water content is removed
DMI	Dry matter intake	The total amount of feed dry matter an animal consumes in a day
EE	Ether extract	Proportion of feed soluble in ether that consists primarily of fats and fatty acids
FE	Feed efficiency	Relative measurement of the efficiency of feed energy use; calculated for lactating cows by dividing the amount of fat- and protein-corrected milk produced by the amount of dry matter intake
FPT	Failure of passive transfer	Inadequate transfer of immunity to a calf resulting from inappropriate colostrum intake or colostrum quality that reduces a calf's ability to fight disease during the first weeks of life
GE	Gross energy	Total amount of energy in feed delivered to a cow
GHG	Greenhouse gas	An atmospheric gas that absorbs and emits radiation within the thermal infrared range
IOFC	Income over feed cost	The difference between the value of product and total feed cost
IOPFC	Income over purchased feed cost	The difference between the value of product and purchased feed cost

Abbreviations and Definitions

LPC	Laboratory pasteurization counts	Estimate of the number of bacteria in a milk sample that can survive pasteurization temperatures. It is obtained by counting bacterial colonies that grow on agar plated with a laboratory pasteurized milk sample. LPC is not a required regulatory test and is quantified as colony forming units (CFU) per ml
ME	Metabolizable energy	Amount of energy remaining after subtracting gas and urinary losses from DE
MP	Metabolizable protein	True protein that flows from the rumen and is digested and absorbed from the small intestine as amino acids
MUN	Milk urea nitrogen	Concentration of urea in milk that may be used to indicate excess nitrogen in a lactating dairy cow diet
NDF	Neutral detergent fiber	Proportion of feed insoluble in neutral detergent and primarily composed of fibrous carbohydrates that include cellulose and hemicellulose plus the indigestible compound lignin; forages are major contributors of dietary NDF
NE	Net energy	Amount of dietary energy available to the animal for productive purposes; it is calculated by subtracting energy loss due to heat production resulting from digestion and metabolism from ME
NEL	Net energy for lactation	Amount of net energy available to the animal to produce milk
NFC	Non-fiber or Non-NDF carbohydrate	Diverse fraction of carbohydrates soluble in neutral detergent provides energy to ruminal microbes, calculated as 100% − (CP% + NDF% + EE% + Ash%)
NH3	Ammonia	Produced by ruminal microbes during protein digestion in the rumen
NPN	Non-protein nitrogen	Refers collectively to nitrogen-containing compounds in feed that are not proteins but can be converted into proteins by microbial activity in the rumen
RDP	Rumen-degradable protein	Feed protein digested by the ruminal microbes
RUP	Rumen-undegradable protein	Protein that escapes microbial digestion in the rumen
SARA	Subclinical acute acidosis	A disorder of ruminal fermentation that is characterized by extended periods of depressed ruminal pH below 5.5 resulting from feed ration imbalances
SCC	Somatic cell counts	Refers to the concentration of somatic cells, primarily leukocytes or white blood cells, present in a milk sample. It is a measure of the response to pathogenic bacteria in the udder and an indicator of milk quality. SCC is quantified as cells per ml
TMR	Total mixed ration	A method of feeding dairy cattle whereby all feedstuffs, including forages, grains, and supplements are weighed and blended into a complete ration providing all nutrients required by the animal
VFA	Volatile fatty acids	Energy-rich products of microbial fermentation of feed that are a main energy source for dairy cattle

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