# Implementing a Nutritional Management Strategy to Enhance Fertility

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## Take Home Messages

- Dairy cow breeding programs have emphasized the selection of traits that increase milk production while maintaining or increasing the concentration of milk fat and protein.
- Increased milk production has placed an increased metabolic load on the dairy cow, especially during early lactation.
- Feeding and management strategies can be implemented to support high milk production and to reduce the metabolic strain on the high producing dairy cow.
- Nutritional management strategies that optimize energy metabolism, protein metabolism and mineral metabolism can be utilized to improve fertility.
- Strategies that minimize the severity and duration of negative energy balance, and associated decreased levels of blood glucose, elevated NEFA and ketones have been shown to improve fertililty.
- Protein nutrition can also be optimized to control the peaks in circulating blood urea nitrogen that has been linked to impaired reproduction.
- Maintaining proper calcium metabolism improves the nutrient utilization and helps prevent disturbances in energy metabolism.
- Proper antioxidant nutrition (selenium and vitamin E) also aids in reproductive function directly as related to decreased incidence of retained fetal membranes.

## Introduction

The modern dairy cow is the product of selection pressure that maximizes the animal's genetic ability to secrete milk. Data was summarized by Washburn et

al. (2002) using DHIA records from 10 states in the southeastern United States. The summary showed that from 1976 to 1999 annual milk production increased from 6802 to 8687 kg for Holsteins and changed from 4753 to 6375 for Jerseys. Concurrent with this increase in milk production, the same herds reported an increase in days open with Jersey herds experiencing an increase of 30 days (112 to 152 days open) with Holsteins having an increased days open of 44 days (124 to 168 days open). Both breeds experienced an increase in services per conception of 1, with the breeds going from 1.9 to 2.9 between 1976 and 1996. This biological relationship between milk production and reproduction is not limited to cattle housed and managed in the United States. As Lucy summarized in an extensive review (2001), maintaining the efficiency of reproduction in high producing dairy cows is a challenge facing the global dairy industry. Numerous reports from scientists from several different countries have found similar changes in reproductive function of the high producing dairy cow.

However, Lucy also discussed a more important issue pertaining to production and reproduction. High levels of milk production, per se, are not necessarily the cause of reduced fertility or poor reproductive performance. He noted that disease and season of calving and overall management were actually more important to maintaining successful reproductive management performance.

Thus, it is very appropriate that dairy farm managers and their consultants recognize the importance of nutritional management strategies in realizing reproductive management goals. Nutritional management strategies that affect reproduction are those that reduce the metabolic strain created by high levels of milk production. The nutritional management strategies that reduce the risk of metabolic disorders associated with the metabolic strain the cow experiences during transition and early lactation are the keys to success. The nutritional strategies most important to having a positive impact on fertility and reproduction are associated with:

- Improving energy metabolism during the periparturient period through early lactation;
- Enhancing efficiency of protein nutrition and metabolism during early lactation (especially at the time of breeding);
- Optimizing vitamin and mineral nutrition during transition associated with normal muscle function (calcium) and immune function (selenium and vitamin E).

## ■ Impact of Energy Metabolism on Fertility

Energy balance has long been the focus of dairy nutritional management strategies. With the steady progression to higher and higher levels of milk

production, the energy requirements of the dairy cow are increased while her capacity for intake remains fairly constant due to physiological constraints of the digestive system (gut fill) and the limits to how much high energy ingredients can be added to the diet before causing ruminal acidosis. Yet, during the last ten years, research has proven that energy metabolism and overall energy balance during transition and early lactation is important to fertility of the dairy cow.

As cows approach calving there is a decrease in feed intake of 25 to 40% (Grummer et al., 2004). Three weeks prior to calving, cows and heifers averaged DMI of 2.0 and 1.7 percent of body weight but declined to 1.4 and 1.3%, respectively, on the day prior to calving. The cause of the decline in feed intake during the periparturient period has been not fully elucidated (Grummer et al., 2004). However, there are some data that suggest the endocrine change affects appetite and thus reduces feed intake around calving. The decrease in feed intake combined with the initiation of lactation and colostrum synthesis begins a period of negative energy balance that lasts through the early stages of lactation. Around calving, the metabolic strain of this negative energy balance is assessed by monitoring blood levels of glucose, non-esterified free fatty acids (NEFA) and ketones. The NEFA are fatty acids released from adipose tissue in response to the drop in dry matter intake around calving and the release of NEFA are stimulated by the hormonal signals related to calving. Excessive mobilization of NEFA from adipose tissue leads to the accumulation of fat in the liver that disrupts normal energy metabolism in the liver.

Excessive elevation of NEFA and ketone bodies in the blood of the periparturient dairy cow has been shown to have a negative impact on reproductive function and fertility.

The negative energy balance immediately after calving is the result of a rapid increase in milk production, with a slower increase in feed intake, or more specifically, energy intake increases at a slower rate than the increase in milk production. The result of this imbalance is a period of negative energy balance when milk energy excreted is higher than the energy consumed. The cow then mobilizes body fat to meet the demand for energy and meet the shortfall between intake and output. The negative energy balance is seen as the change in the body condition score. The severity and duration of the negative energy balance has been shown to affect reproduction and fertility. Pryce et al. (2001) reported a relationship between body condition score and fertility.

## Strategies to Enhance Energy Balance and Metabolism to Improve Fertility

Nutritional management strategies to improve energy balance and metabolism have been developed with an expectation that improved energy balance and metabolism will improve reproduction.

- Optimize feed intake by minimizing the drop in DMI just prior to calving and through early lactation.
    - Ideal feeding system and feeding environment
    - Use of fibrous byproduct feeds
    - Use yeast to improve diet fermentation and intake
    - Maintain normal mineral metabolism
- Use supplements that improve fat utilization/energy metabolism such as:
    - Rumen protected choline
    - Niacin
    - Chromium
    - Monensin
    - Propylene glycol

## Impact of Protein Nutrition on Fertility

As is the case with energy, increasing milk production has also increased the requirement for protein intake. Much progress has been made in protein nutrition in terms of formulating diets for dairy cattle. Several extensive reviews describe the current approach to the formulation of protein fed to dairy cattle. What was originally a nitrogen based system that utilized crude protein, current diet formulation not only considers the amount of total nitrogen in the diet, but also incorporates the location in the digestive tract that the feed is digested (rumen degradable versus rumen undegradable protein). These systems also use prediction models to incorporate rate of passage, rate and extent of carbohydrate fermentation, as well as rate and extent of rumen degradability to predict amino acid flow relative to the amino acid requirements of the animal.

An imbalance among any of these variables can lead to the inefficient use of protein by the dairy cow. The metabolic outcome of an imbalance is an increase in the concentration of urea, a non-protein nitrogen waste product of protein metabolism. An increase in circulating urea levels has been associated with reduced fertility. Butler (1998) completed an extensive review of this topic and reported several mechanisms may be involved. Possible mechanisms leading to impaired reproductive function as a result of elevated blood urea nitrogen levels include, an indirect effect through energy utilization (during early lactation when the cows are already in a negative energy balance), reduced

fertility due to an altered uterine environment that is not suited for optimizing fertility or maintaining pregnancy, or altered endocrine profiles in response to the elevated blood urea concentrations.

Milk urea nitrogen (MUN) measurements have been introduced in recent years to be used as a diagnostic tool to assess the utilization of dietary nitrogen. In large part, MUN testing has found its greatest application to evaluating the potential negative effect of protein nutrition of a herd and reproduction of cows within the herd. Guo et al. (2004) evaluated the relationship between MUN and reproductive performance of more than 10,000 cows managed in over 700 herds in the Lancaster County DHIA in Pennsylvania. These scientists concluded that across herds, the impact of MUN was inconsistent, but within herds, MUN was related to fertility as measured as a decrease in conception rate with an increase in MUN. Similarly, MUN was shown to decrease pregnancy rate in a study published using data from Israel's DHIA (Hojman et al., 2004).

## ■ Strategies to Enhance Protein Balance and Metabolism to Improve Fertility

Nutritional management strategies to improve protein balance and metabolism have been developed with an expectation that improved protein balance and metabolism will improve reproduction.

- Optimize the balance of types of protein to reduce the production of ammonia in the rumen to avoid excessive spikes of ruminal ammonia leading to spikes in blood urea.
- Optimize the balance and synchronization of protein and carbohydrate fermentation to improve the utilization of nitrogen by rumen microorganisms.
- Optimize the amino acid balance through careful diet formulation.
- Avoid overfeeding total protein by assessing protein intake rather than only considering concentration of protein in the diet (kilograms versus percentages).

## ■ Impact of Vitamin and Mineral Nutrition on Fertility

Most dairy farmers are familiar with the effects of vitamin E and selenium on reproductive performance. Indeed these two antioxidants are important nutrients to consider when evaluating the relationships that exist between nutrition and reproduction in the high producing dairy cow. However, many dairy producers fail to recognize the importance of other minerals.

For example, what role does calcium serve in maintaining reproductive performance of dairy cattle? Calcium does not normally receive much discussion in the topic of nutrition and reproduction. And given the lack of data showing a direct effect, this is certainly understandable. However, during the transition phase, optimizing calcium status has been shown to have important positive effects on energy metabolism and balance. Moore et al. (2000) reported cows fed an anionic diet with a DCAD of -15 meq/100g of diet tended to have lower liver triglyceride levels at calving although there was no difference in NEFA levels prior to calving. In unpublished data from the Dairy Nutrition Research lab at the University of Missouri, cows fed a diet with -10 DCAD had similar intakes prepartum with significant lower NEFA during the periparturient period. The data suggests that improving calcium status improves the utilization of ingested nutrients, specifically energy, leading to a lower metabolic strain on the cows during transition.

Vitamin E and selenium as mentioned before are the nutrients most often discussed pertaining to reproduction. Vitamin E and selenium have been associated with the incidence of retained fetal membranes. These antioxidants are also associated with immune function and udder health. Mammary gland infections can reduce fertility and the benefits of improved immune function may have indirect benefits on reproduction.

## ■ Strategies to Enhance Vitamin and Mineral Balance and Metabolism to Improve Fertility

The proper balance of these important nutrients must be provided to assure the animal is consuming adequate amounts. Excessive intake of certain minerals can disrupt the digestibility of other minerals, therefore, the balance of all minerals is important. Certain minerals, such as calcium, influence muscle function. Strategies to minimize metabolic disorders associated with inadequate circulating levels of calcium must be implemented. This includes controlling calcium, potassium, and sodium intake to minimize the risk of milk fever. In some cases, the inclusion of anionic salts to alter metabolism to foster calcium metabolism will be a better alternative for preparing the cow to support the onset of lactation.

## ■ Summary

Increased milk production has increased the metabolic strain on the dairy cow. High production, in and of itself, does not cause a decrease in fertility and reproductive performance. Rather high production increases the importance of excellent management to achieve high levels of milk production while also achieving reproductive management goals that maximize efficiency and profits.

Loeffler et al. (1999) summarized the relationship with the following:

> "In general, nondisease parameters have affects on a larger number of inseminations than do disease parameters. Consequently, a great potential for improving herd fertility lies in the improvement of non-disease parameters such as reduction in BCS loss or improvement of feeding or environmental factors causing conception rate in a particular season or year to be much lower."

In other words, nutritional management is one part of a total management system that must be in place to assure animals achieve their genetic potential for milk production while not compromising their biological ability to become pregnant.

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