

A BAMN Publication
A GUIDE TO FEEDING AND WEANING HEALTHY AND
PRODUCTIVE DAIRY CALVES



Introduction

The purpose of the guide is to provide dairy producers with the most effective feeding and management programs to optimize growth and maximize health for dairy calves through the weaning period.

Key Messages

General Feeding Recommendations and Weaning Criteria

- **Milk Feeding** - Feed high quality milk or calf milk replacer for at least 6 weeks. Feeding milk for a longer period will benefit calves. An ideal feeding program is one in which milk intake is based on birth weight, desired daily calf weight gain, calf health, and climactic conditions.
- **Water** - Offer easy access to fresh, clean, high quality water at all times starting on day 1 of age.
- **Calf Starter** - Offer high quality dry calf starter (22-25% crude protein dry matter) within the first seven days of age. Offer small handfuls at each feeding the first few days.
- **Weaning Criterion** - Consumption of calf starter should be the primary criterion for determining time of weaning. Calves can be weaned when they are consuming at least 1.4 kg (3 lb) of starter daily for 3 consecutive days. The calf **MUST** be healthy before it is weaned.
- **Weaning Age** - Minimum 6 weeks (42 days) and consuming at least 1.4 kg (3 lb) of starter daily. Wait until calves are at least six weeks old before discontinuing milk feeding. The ruminant phase of the digestive system development will not be mature enough to sustain growth before 6 weeks of age.
- **Weaning Method** - Acceptable weaning practices include reducing milk offered (step down) and reducing solids concentration in milk/milk replacer. If calf starter intake is low, discontinue one feeding per day of milk or milk replacer for a minimum of 7 days prior to weaning. Keep calves in same housing for 1 week after weaning to reduce stress.
- **Hay** - Hay has its place in the diet once the rumen is fully functional, after weaning. Small amounts of finely chopped fiber in calf starters (3-5% of DM) may help prevent bloat in calves consuming large amounts of starter. Wet forages are not recommended because of reductions in intake and the possibility of spoilage.

The [National Animal Health Monitoring System's \(NAHMS\) Dairy 2014](#) study was conducted by USDA-APHIS in 2014 and surveyed 1,261 dairy farms in the top 17 dairy states (USDA, 2016). Results from the study showed that some dairy producers were not following the optimal nutrition and management guidelines that help produce healthy calves that are weaned in a timely and cost-effective way.

Below are a few findings from the NAHMS Dairy 2014 study related to weaning:

1. **Criteria used to determine weaning time.** Calf age was the primary factor for 50.2% of producers, grain intake for 21.5%, and weight for 21.3%.
2. **Weaning age.** On average, calves were weaned at 9 weeks of age. Over 60% of producers weaned calves at an average age of eight weeks or more. Less than 8% of producers weaned calves at six weeks of age or less.
3. **Water.** On average, water was first offered to calves at 17.3 days of age.
4. **Grain.** On average, calves were offered the first grain at 10.8 days of age
5. **Forage.** On average, most operations offered hay to calves at just over one month of age (36.0 days).

This study indicates the need for a much wider application of current knowledge of nutritional science in deciding when and how to wean dairy calves.

I. Development of the Digestive System

Ensuring that calves are healthy at weaning requires a basic understanding of the calves' digestive process and the changes that occur to the process from birth to weaning. From birth to approximately three weeks of age, calves totally depend on milk or milk replacer for their nourishment. After 3 weeks, calves usually receive a combination of milk and calf starter for a varying length of time. This combination provides the necessary nourishment to the calves and promotes the development of the calves' rumen, which provides calves with energy and protein by fermenting dry feed.

The development of calves' digestive system occurs in three phases:

1. **Preruminant** (monogastric) – This phase begins at birth and continues until the 3rd or 4th week of life. At this stage of development, the abomasum, or true stomach, is the main site of digestion. This phase will last longer if the introduction of calf starter is delayed.
 - Colostral absorption phase – Refers to the short period of time when the intestine has the ability to absorb the large molecules found in colostrum, such as immunoglobulins. After calves are 24 hours of age, their intestines are no longer able to absorb these molecules.
2. **Transition** – This phase begins around the 3rd or 4th week of life and continues as long as calves are offered milk or milk replacer. Once calves start to eat dry feed, rumen fermentation begins. Production of volatile fatty acids (VFA) from carbohydrate fermentation is responsible for rumen development.
3. **Ruminant** – This phase begins once milk or milk replacer is no longer fed to the calf. Dry feed is the sole food source. The rumen becomes an important component of the digestive tract. Rumen microorganisms break down feedstuffs to produce microbial protein and VFA.

Prior to weaning, most of the energy and amino acid needs of calves are derived from intestinal digestion of milk or milk replacer. When calves begin consuming water and starter, bacterial fermentation in the rumen begins to produce larger amounts of the VFAs – acetate, propionate, and butyrate. Production of VFAs are responsible for rumen tissue development with butyrate and propionate being primarily responsible for developing the metabolic activities of the rumen. Rumen development is important and necessary for calves to transition from a monogastric to a ruminant.

Research has demonstrated that readily fermentable carbohydrates, such as those in a high quality calf starter, result in a higher production of VFAs compared with the complex carbohydrates in forages. This research shows that feeding forage prior to weaning does not prepare calves for a smooth weaning transition.

Hay fed to young calves prior to weaning may slow rumen development. Opinions differ as to whether or not forage should be included in the preweaning diet. Numerous nutritional factors should be carefully considered when deciding whether to include forage in the preweaning diet. Wet forages, such as haylage, should be excluded from the diet of preweaned calves due to their inadequate rumen capacity and tendency to spoil and become unpalatable. While feeding hay to young dairy calves before weaning is a common management practice on some farms, rumen development will be optimized if hay is reserved for weaned calves. Small amounts of fiber in calf starters, however, may help prevent bloat when calves are consuming large amounts of starter.

II. Feeding Program

To achieve a smooth transition through the three phases of digestive system development (Table 1), it is essential that a sound and well-managed feeding program is begun immediately after birth. The goal of this program is to give the calf a healthy start for the rest of its life. The first steps are assuring that the immune system can start functioning and that the necessary nutrients for good growth are provided.

A. Colostrum

Colostrum plays a critically important role in calf immunity by supplying antibodies and other immune factors until the calves' own immune system is more developed. Equally important, however, is the nutritional role of colostrum, which contains a high concentration of nutrients essential to starting the digestive processes in the intestines. Recent studies have demonstrated that colostrum management on U.S. dairy farms is improving. The NAHMS Dairy 2014 study demonstrated an increase in the percentage of newborn calves that are getting enough high quality colostrum (IgG > 50 g/L), resulting in a higher percentage of calves with good

or excellent blood levels of IgG. A separate BAMN publication on colostrum addresses these points in detail, [*A Guide to Colostrum and Colostrum Management for Dairy Calves*](#).

B. Milk or milk replacer

Until the rumen starts supplying energy and microbial proteins in quantities sufficient to maintain growth, calves must get high quality milk or calf milk replacer (see previous BAMN publications on quality milk feeding). Emphasis must be placed on both the quality of milk or milk replacer as well as the quantity given. Sanitizing feeding and mixing equipment before each use along with properly handling and storing milk or milk replacer are essential to avoiding bacterial contamination that may lead to health problems in calves.

Bacterial contamination of milk is frequently evaluated using standard plate counts. For any milk or milk replacer fed to calves, it is recommended that total plate counts are < 20,000 CFU/ml and the total coliform counts are < 10 CFU/ml. These levels are required of Grade A milk for human consumption (FDA 2015) and are achievable if milk is harvested properly and pasteurized using clean equipment. Feeding pasteurized waste milk to calves has been shown to result in better overall health and growth compared with feeding raw milk. (Jammaluddin et al., 1996)

It is not economical to use a lower cost/quality milk replacer. It has been argued that feeding lower quality milk replacer for a longer period will produce a better result than feeding a high quality milk replacer or whole milk for a shorter period. Research in this area has demonstrated that feeding a high quality liquid feed will lead to better early growth, higher rates of survival and earlier dry feed intake than feeding lower quality liquid feed. Too frequently, poor quality milk replacers are offered in low quantities during the all-critical first two weeks of life. This practice results in poor growth and poor health. Without adequate nutrition, calves will not grow to their potential and their immune system will not optimally develop, predisposing them to disease, particularly scouring and respiratory problems. Calves must grow if they are to have adequate calf starter intake to promote the necessary VFA for rumen development.

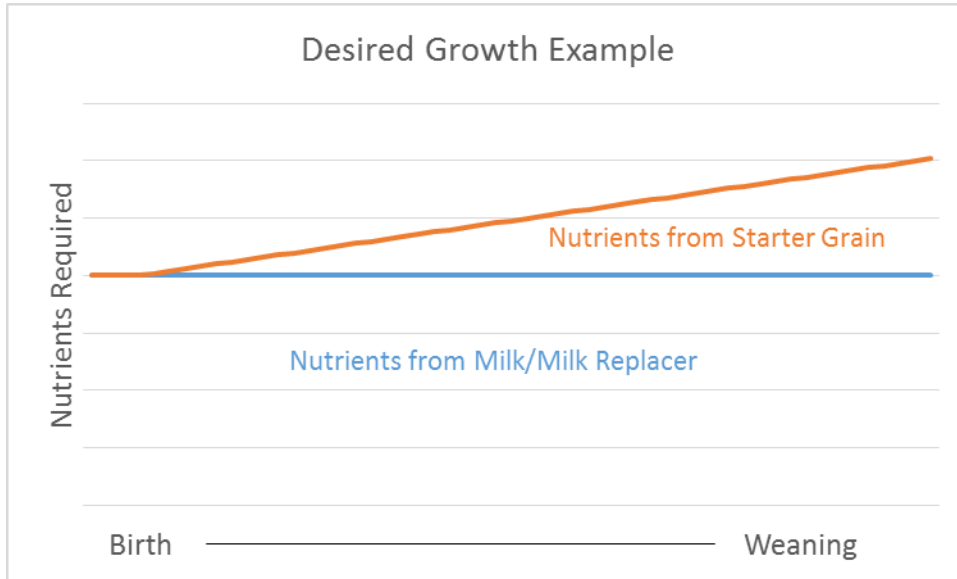
Feeding and management programs for calves are designed to help ensure that calves' meet their biological growth potential. Optimally, calves should double their birth weight by 8 weeks following birth. Many milk feeding programs for calves suggest a specific quantity of milk or milk replacer be fed two or three times daily for up to six to eight weeks. The daily feeding rate for milk or milk replacer should be based on desired weight gain, calf weight, calf health, and climatic conditions. These feeding and management programs advocate feeding calves 15-20% or more of their birth weight in milk or milk replacer (mixed at 12-15% DM) daily. For example, a Holstein calf would receive 0.9-1.1 kg (2-2.5 lb) per day of dry matter from milk or milk replacer (i.e., 7.6-9.5 L [8-10 quarts]/day). Specifically designed milk replacers, calf starters, and feeding and management procedures must be followed to optimize calf performance on these programs. For more detailed information on calf milk replacers refer to BAMN publication, [*A Guide to Calf Milk Replacers*](#).

It is vitally important that milk feeding programs be adjusted for climatic conditions. For example, during warm months a 41 kg (90 lb) Holstein calf should be fed a minimum of 0.7 kg (1.5 lb) of milk replacer solids or 5.5 kg (12 lb or 6 quarts) of milk per day. When calves are housed outside in hutches and environmental temperatures fall below 10-16°C (50-60°F), feeding the amounts above is inadequate to meet maintenance requirements. During periods of cold weather, calves use energy to maintain their body core temperature; consequently, that energy is not available for growth or for maintaining other body functions, such as the immune system. In cold weather, calves should be fed 50% more whole milk or reconstituted milk replacer, thus providing more dry matter. This additional milk/milk replacer may be offered in a third feeding. The 2001 Nutrient Requirements of Dairy Cattle (National Research Council, calf computer model <https://nanp-nrsp-9.org/nrc-dairy-model/>) is a useful tool for fine-tuning daily feeding rates of milk replacer, relative to environmental conditions and desired weight gains.

A calves' passive transfer status and the amount of liquid nutrition consumed during the preweaning period plays an important role in resistance to disease and growth. Research has demonstrated that calves with preweaning disease (e.g., scours, pneumonia) usually have lower average daily gains than calves without preweaning disease. This effect of strong immunity and increased milk consumption during the preweaning period, while improving average daily gain, also impact future productivity. Increasing the nutrient intake (i.e., milk or milk replacer) of calves from birth to 56 days of age has been shown to increase milk yield during the first lactation (Soberon et al., 2012; Moallem et al., 2010). Feeding more milk to preweaned calves generally results in healthier calves and higher milk production in first and maybe subsequent lactations.

Figure 1 below depicts the recommended nutrients required to meet a desired growth rate in preweaned calves. Calves should be fed large amounts of milk/milk replacer from birth through the preweaning period. Calves can increase starter intake as they need more nutrition to meet their desired growth.

Figure 1. Nutrient Sources for Preweaned Calf Growth



C. Water

Water is critical to the health of calves, rumen development, and hydration. The amount of water calves need fluctuates based on temperature and humidity. Drinking water encourages calves to eat dry feed earlier. In addition, calves that received free choice water from birth to 4 weeks of age had a higher daily weight gain, consumed more calf starter, and had fewer scour days than calves not receiving free choice water. A research trial comparing the performance of calves receiving free choice water with calves that received none is shown in table 1.

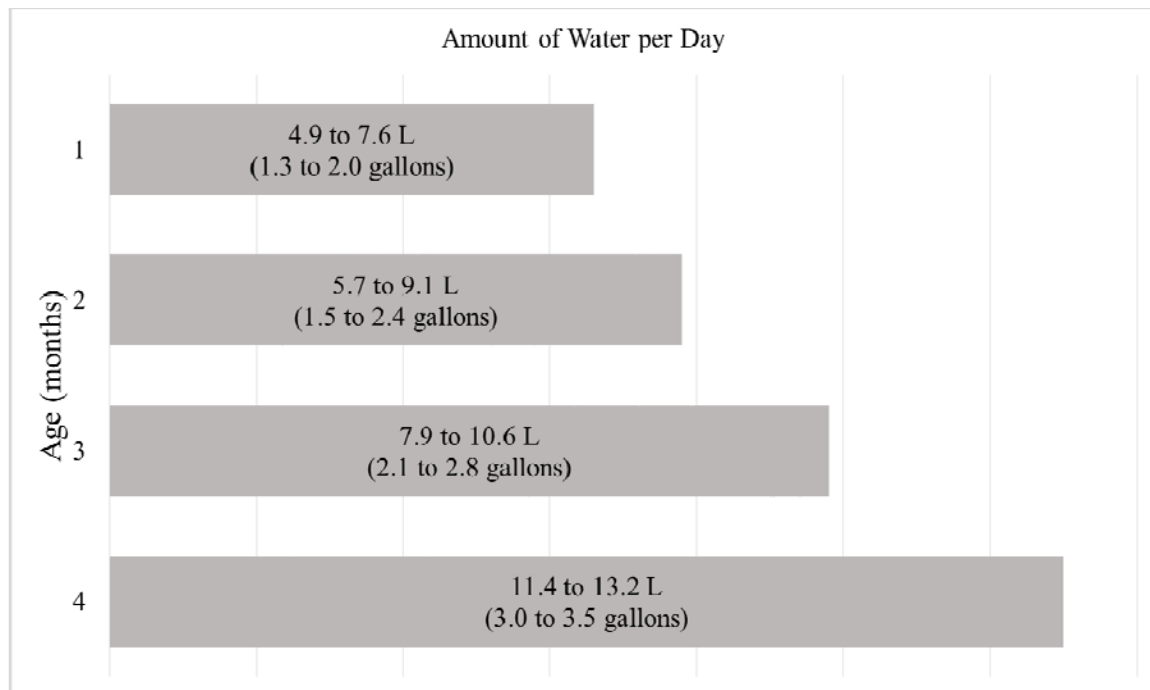
Table 1. Effect of Free Choice Water on Calf Performance*

Parameter	Water	
	Free Choice	Not Offered
Daily Gain, kg (lb)	0.31 (0.68)	0.18 (0.40)
Calf Starter Intake, kg (lb)	11.8 (26)	8.2 (18)
Scour Days Per Calf	4.5	5.4

*Kertz, A. F. 1984. Journal of Dairy Science 67:2964-2969

Milk or milk replacer are not substitutes for water. Water should be freely available to calves at all times, and it should be fresh, clean, and of good quality. Figure 2 below provides guidelines on the amount of water calves should be consuming per day at different ages. Poor water quality can result in insufficient water intake or health problems in calves. For example, high sulfates, sodium, iron, nitrates, or bacterial contamination of water sources can cause calf health problems. In cold weather, it is important to frequently provide calves with warm water (warm to the touch), if possible.

Figure 2. Guidelines for Drinking Water for Calves
(These amounts are in addition to milk or milk replacer)



D. High Quality Calf Starter

Calf starter comes in a variety of types, from pelleted complete rations to proprietary coarse-textured mixtures that often consist of cereal grains and pelleted protein concentrate. Unfortunately, there is no simple test for measuring the quality of calf starter, but freshness and palatability are important.

Calves should be offered small handfuls of starter at each feeding the first few days of life. Discarding unconsumed calf starter daily is important in maintaining starter freshness. Calf starter must be palatable, contain minimal fines, and provide sufficient energy in the form of readily fermentable carbohydrates to provide rapid rumen development. Typically, good calf starters contain 22 to 25% crude protein (dry matter basis), typically 20-23% crude protein on an as-fed basis, and .52 to .56 Mcal net energy for gain/lb. Consideration should be given to the source and quality of ingredients. Remember, calves' growth does not depend on the "percentage of protein," but rather on the amount of protein and other nutrients they actually consume. Small amounts of fiber in calf starter may help prevent bloat in calves consuming large quantities of starter.

E. Forage (Hay)

Research has shown that the rate of rumen development is related to production of VFA from readily fermentable carbohydrates, which are abundant in high quality calf starters, but are low in forages or hay. In the past, it was often considered important to have hay available either *ad libitum* or in restricted quantities during the first days of life. While calves will eat good quality hay if it is available, hay does not contain either the nutrient density or nutrient profile necessary to stimulate rapid rumen development. Research has shown that allowing calves free-choice access to hay prior to weaning slows rumen development and growth compared with giving calves only a high quality calf starter. Hay and forages have their place in ruminant feeding programs after weaning. After weaning, hay should be introduced as needed to achieve the desired ration energy density for the desired growth rate.

III. Guide to Feeding and Weaning

Table 2. Feeding Guide for Calves by Phase of Development

Phase	Age	Diet Required and Feeding Recommendations
Preruminant (monogastric)	1 day	<p>High quality colostrum (IgG > 50 g/L)</p> <ul style="list-style-type: none"> • Green range on colostrometer OR • 22% on Brix scale <p>Calves should receive 10% of body weight in high quality colostrum within 6 hours of birth. Perform one of the following:</p> <ul style="list-style-type: none"> • Feed 2.8 L (3 quarts) via nipple bottle OR • Feed 3.8 L (4 quarts) by esophageal feeder.
	2-28 days	<p>Milk or milk Replacer – high quality*</p> <p>Adjust the milk feeding program based on calf birth weight, desired daily weight gain, calf health, and climatic conditions. Under normal climatic conditions (15-23°C or 60-75°F), feed a 15-20% of body weight as milk or reconstituted milk replacer daily. For example, a 41 kg (90 lb) Holstein calf should get a minimum of 0.7 kg (1.5 lb) of milk replacer powder per day. In cold weather (<15°C or 60°F), feed 50% more whole milk or milk replacer in a 3rd feeding. Higher protein calf milk replacers along with higher daily feeding rates may be needed to ensure adequate weight gain and health.</p> <p>Calf Starter – fresh and high quality</p> <p>Introduce small quantities (hand full) of high quality calf starter: 22-25% crude protein on a dry matter basis – 20-23% on an as fed basis) on day 4. Keep it fresh and available at all times.</p> <p>Water – fresh, clean, and always available</p> <p>Calves are dependent on free choice water to maintain proper hydration.</p>
Transition	29-41 days	<p>Milk or Milk Replacer – high quality*</p> <p>The amount of milk or milk replacer fed can be decreased by up to 50% in the week prior to weaning, if calves are consuming enough starter.</p> <p>Calf Starter – fresh and high quality</p> <p>Healthy calves should be consuming a minimum of 1.4 kg (3 lb) of 22-25% crude protein (dry matter) calf starter per day for at least 3 consecutive days by the time they reach weaning age.</p> <p>Water – fresh, clean and always available</p> <p>Calves will start consuming significant quantities of dry feed during the 3rd and 4th weeks of life, depending on several factors, including health status; availability of fresh, clean water; and milk replacer feeding programs.</p>
Ruminant	42 days or more (weaning)	<p>Milk or milk replacer</p> <p>Discontinue milk feeding using a step-down approach. Delay weaning if calves are not meeting starter intake requirements above.</p> <p>Calf Starter – fresh and high quality</p> <p>New research shows that calves have higher energy and protein requirements than was previously thought. Thus, be sure to provide plenty of fresh, high quality calf starter.</p> <p>Hay - Hay has its place in the diet once the rumen is fully functional, after weaning.</p> <p>Other Forages – Wet forages are not recommended because of reductions in intake and the possibility of spoilage.</p> <p>Water – fresh, clean, and always available</p> <p>Once calves are weaned, they are dependent on fermentation of feedstuffs in the rumen to provide the majority of their energy and protein.</p>

* See BAMN Publication: [A Guide to Calf Milk Replacers](#).

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1. [*A Guide To Feeding and Weaning Healthy and Productive Dairy Calves*, 2003](#), revised 2017
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