Rumen Development in the Dairy Calf
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Introduction
The dairy calf begins its life as a simple stomached animal, yet spends most of its life as a ruminant whose digestion depends largely on fermentation. The change from one digestive method to another is a process that is called rumen development. A dairy cow has a four-part stomach system consisting of the reticulum, rumen, omasum, and abomasum. The first two compartments make up one large fermentation vat, the third is an unusual looking organ that absorbs water and minerals from digesta leaving the rumen, and the fourth is the true stomach that functions like the stomach of monogastrics (including pigs and people). All four of these stomach compartments are present at birth; however, only the abomasum is fully developed and functional. The other compartments, most notably the reticulum and rumen, are essentially undeveloped in the neonate. The reticulum and rumen are sterile at birth, and it is often several weeks before a constant bacterial population is established that resembles the bacterial population of an adult ruminant.

Feeding Calves
When we think of feeding calves, the first thing that comes to mind is probably milk or milk replacer. Liquid feeds are the primary nutrient source for calves in the first weeks of life, and they bypass the reticulum and rumen via closure of the esophageal groove. The formation of the esophageal groove sends liquid feeds directly into the stomach compartment that will digest them best—the omasum followed quickly by the abomasum...
sum. When we offer nutrient-dense liquid feeds, they provide the needed nutrients for maintenance and growth of young calves. However, milk and milk replacer do not allow for much growth or any maturation of the reticulum and rumen as they are being bypassed. Feed, most notably dry feed, has to remain in the rumen in order to begin the rumen development process. Dry feed, such as calf starter (grain mixtures) or forage, will not pass through the esophageal groove, and thus flows from the esophagus into the reticulo-rumen where digestion begins.

**How a Rumen Develops**

The bacteria that colonize the rumen are obtained from the environment, other animals that the calf comes into contact with, and bacteria found on feeds. Milk often is one of the first sources of rumen bacteria.

When dry feed enters the rumen, it absorbs water that the calf has consumed. That, along with the anaerobic (absence of oxygen) environment of the rumen, provides a perfect place for bacteria to grow. As these bacteria grow and metabolize nutrients, they produce volatile fatty acids. The primary volatile fatty acids produced in the rumen are acetic, propionic, and butyric acids. This acid production lowers the pH of the rumen and establishes an even better environment for bacteria to continue their growth, especially for bacteria that digest starch and produce propionic and butyric acids. Calf starter feeds contain carbohydrates in the form of starch which is fermented by bacteria that produce propionic and butyric acids. When forages are digested, due to the different species of bacteria that digest fiber, the primary end product is acetic acid.

Acetic and propionic acids are absorbed through the rumen wall and are taken up by the blood and pass through the liver to be made into metabolites that can be used for energy sources by the calf. However, butyric acid is not absorbed through the rumen wall, and the cells of the rumen wall have an alternative metabolic process that allows butyric acid to be converted into an energy source for use by the cells in the rumen wall. Thus, butyric acid produced in the rumen primarily provides energy for growth of the rumen wall. Acetic and propionic acids provide energy for the entire calf, part of which is shared to the rumen wall, but overall compared to butyric acid, much less acetic and propionic acids are used to fuel rumen development.

**Develop the Rumen before Weaning Calves**

Research has shown that once a significant amount of starter or grain is consumed by the calf each day (approximately 0.25 to 0.4 lb per day), it takes about 3 weeks to then develop the rumen to the point that this digestive organ by itself has an established microbial population and enough absorptive capacity to allow the calf to continue normal growth once milk or milk replacer is stopped (weaning). If liquid feeds are removed before rumen development has occurred, the calf will not grow and may even lose body weight for 1 to 3 weeks until the time that the rumen is developed.

Therefore, digestion of starch sources is a major component of rumen development, and calf raisers should provide feeding, housing, and management practices that encourage calf starter intake and thus rumen development. Many dif-
different studies in countries throughout the world have confirmed the feeding and management practices that inhibit calf starter intake. Classically, a poor housing environment that creates sick calves will reduce appetite and intake. Overfeeding milk or milk replacer (> 14% of body weight per day) reduces calves’ appetite for dry grain. Unpalatable, dusty, or moldy starters will also reduce calf intake. Free choice water is needed, as well as clean buckets for feeding both water and grain. Any time you notice 2-week-old calves that are not eating grain, stop and determine why they are not eating it. If they are not eating a half pound a day by 4 weeks of age, again, look for the cause.

Body weight gains from calf starter are always going to be cheaper gains than from milk, but both are needed in the young calf. Early weaning programs (35 days or less) require great attention to starter intake as the rumen will not be fully developed by the time milk feeding is reduced; however, with good management, these programs can be very successful. If high levels of milk are fed which restricts grain intake, it may still take 3 additional weeks of high grain intakes for rumen development to occur even if weaned at 8 to 10 weeks of age.

Any time we evaluate the cost of feeding and maintaining a dairy replacement animal, the preweaned calf is always found to be the most expensive per day (primarily labor and feed), while the first group after weaning is the very least expensive replacement animal. Thus, age at weaning and heifer economics go hand in hand. Obviously, weaning at a reasonable age is only part of the equation, as we want calves to continue to grow at all stages. Thus, rumen development is the key.

Calves are born with undeveloped rumens, yet they will spend the vast majority of their lives as ruminants. Our job is to allow calves to make the transition easily and in a timely manner so that they grow to be cost-effective forage consumers that are efficient and productive animals.

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Colostrum Management
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Introduction

Nothing has a greater impact on the newborn calf’s survival than colostrum. However, what is colostrum and how can we manage it for proper passive transfer? Colostrum is defined as the first secretion of milk after parturition and is invaluable for calf health. Calves are born with a naïve immune system that relies on the maternal antibodies in colostrum.
for protective immunity. This means that a calf will have to drink colostrum in order to develop active immunity. The composition of colostrum differs from whole milk and varies from cow to cow in many ways particularly nutritive value and the percent of antibodies or immunoglobulins (Ig). The Immunoglobulins are needed by the calf to help identify and destroy bacteria. There are three main immunoglobulins in colostrum is IgG, IgM and IgA with IgG making up 85% of the total volume. Insufficient consumption or low quality colostrum will lead to failure of passive transfer of immunity (FPT). In spite of this many do not measure colostrum on a regular basis. First let’s go over some key factors that will enhance our colostrum management – Quickly, Quantity, Quality and Cleanliness.

Quickly

The design of the calf’s digestive tract allows for temporary absorption of antibodies which declines rapidly during the first few hours of life. Furthermore, if a calf has not received colostrum by 12 hours of age it is likely that the calf will have inadequate passive transfer and anything that the calf may ingest prior to colostrum is also absorbed be that of manure or bedding which can lead to greater risk of high calf mortality. The ability to absorb immunoglobulins is virtually gone by 24 hours of age therefore it is imperative that a calf receive colostrum as soon as possible after birth ideally before 4 hours of age. Hand-feeding of colostrum is the only true way to ensure that a calf receives the proper amount within the recommended time frame. In addition, colostrum has a high nutrient value that supplies the calf with a concentrated source of fat, protein, vitamins and minerals. Always remember to use clean equipment when feeding the calf.

Quantity

Now that we know to feed the calf as soon as possible after birth how much colostrum should a calf receive? The average 90 pound Holstein calf should receive 10% of her body weight or 4 quarts of colostrum within 4 hours of birth and another 2 quarts 8-12 hours later. The absorption of antibodies seems to be very inefficient with an average of only 25 to 30 percent of the antibodies consumed reaching the calf’s bloodstream. The more colostrum you can get in the first feeding the better the chances of adequate IgG being absorbed in the gut prior to closure.

Quality

There are many factors that can have an impact on the amount of Ig in colostrum. The dry cow period should be 3-4 week minimum to have acceptable levels of Ig. Older cows have a higher concentration of Ig than first-calf heifers. In addition, Holsteins have a lower concentration than other breeds with Jerseys having the highest. The amount of milk that is produced during the first milking will also dictate the Ig concentrations. A general rule (18 lb. rule) is that greater than 18 pounds of milk produced in the first milking will have a lower Ig concentration than a smaller volume. The Ig content of colostrum can vary from 2-15 percent but on average the Ig content of colostrum is 5 to 6 percent which equals 50-60 g/L.
Cleanliness

We have learned the three Q’s of colostrum management: Quality, Quantity and Quality. Now we need to keep it clean. To keep colostrum clean we must make sure that the udder, milking equipment, feeding equipment is clean before collecting it from the cow. Contamination of the colostrum will result in a lower quality product and introduce harmful bacteria into the calf’s system. Bloody and mastitic milk should not be fed as well. Milk is 87% water and is a great breeding ground for bacteria. To slow down bacteria growth place the colostrum in the refrigerator if you plan to use it within 24 hours, greater than 24 hours freezing is recommended. Prior to feed you can thaw the colostrum in 110°F - 120°F water bath. Pasteurizing colostrum at 140°F for 30 minutes reduces the bacteria count and has shown to increase the efficiency of Ig absorption. However, pasteurization will not overcome poor quality colostrum.

Testing

The actual measurement of colostrum can be obtained by using commercial devices. The Brix Refractometer which measures the amount of light that is bent as it passes through the liquid is an effective on-farm tool that is rapid, accurate and easy to use. Brix Refractometers range from $50-$500 depending on the model that is chosen. The refractometer is commonly used to measure sugar content in products but can also be used to measure Ig in colostrum. A standard optical Brix Refractometer will have a scale of 0-32%. A Brix score of >21% means high antibody levels in the colostrum and can be used for the first feeding. A score of 18-20%, the milk can be used as a second or third feeding. The score of <17% means the Ig levels are low and the colostrum is of poor quality.

To use the optical Brix Refractometer you place a few drops of the liquid on the glass plate and read the results through the eye-piece. The amount of light bent by the sample will form a line on the scale. The digital refractometer is more expensive but a score is displayed on the digital read out after a few drops of liquid are placed in the well.

Summary

Colostrum management is crucial. The survival of the calf is dependent on the transfer of passive immunity obtained from the immunoglobulins in colostrum. The proper quantity and quality of clean colostrum should be feed quickly. Another way to remember is the “4-4-4 Rule”: Milk the cow within the first 4 hours of calving, feed the calf within the first 4 hours of birth with 4 quarts of clean high quality colostrum. No calf should be born without being fed colostrum. Following these tips can increase the survival rate of your calves.

The Extension office has a refractometer that is available to test your colostrum. If you would like more information feel free to contact Dan Severson at severson@udel.edu or call 302-831-8860.

References are available upon request.
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Reduced-Lignin Alfalfa: A New Era in Alfalfa Genetics?

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Until recently most efforts at improving alfalfa yield and quality have wound up as a case of “Yeah but…”:
“Multileaf alfalfa varieties sure look great, with 5 to 7 leaflets instead of the normal 3.” Yeah, but research hasn’t found any improvement in yield or forage quality, probably because there’s little difference in the leaf-stem ratio on a weight basis. There are more leaflets, but each one is smaller.
“Today’s alfalfa varieties have much-improved disease resistance, many resistant to four or five foliar diseases.” Yeah, but resistance to a disease makes a difference only if the disease is present, and often it is not. And the aggressive harvest management practiced on many farms often depletes stands before disease has a chance to take its toll. I’ve been telling farmers for many years that alfalfa doesn’t die—we kill it by cutting it at the bud stage (which reduces nutrient reserves) and by crown damage caused by wheel traffic.

Until recently plant breeders have been frustrated in their efforts at improving alfalfa forage quality while maintaining competitive yields. As Cornell University plant breeder Julie Hansen commented to me several years ago (in referring to alfalfa breeding efforts), “In general, selecting for improved forage quality tends to result in populations with lower yields.” There seemed to be a link between alfalfa yield and quality: Improve forage quality and yield suffered. This link now appears to have been broken with the development of reduced-lignin alfalfa varieties that feature better forage quality with equal or—depending on harvest management—perhaps even higher yield. Hi-Gest varieties, sold by Alforex Seeds, are non-GMO and are 7-10% lower in lignin vs. conventional alfalfa varieties. HarvXtra varieties are sold by several seed companies including Dupont-Pioneer and Monsanto/Dekalb. HarvXtra alfalfa is a GMO, all HarvXtra varieties are Roundup-Ready, and they’re 12-18% lower in lignin. Reduced lignin varieties don’t have a slower rate of increase in lignin; lignin is lower at all stages of plant maturity.

Not surprisingly, reduced lignin alfalfa is more expensive than conventional varieties, with HarvXtra varieties carrying a technology fee of $300 per 50-lb. bag for the Roundup Ready and reduced lignin traits. These costs need to be balanced by the potential for higher milk production, which of course will differ among farms.

Farmers growing reduced-lignin alfalfa varieties have a decision to make: Should they delay harvest until early bloom (up to 25% bloom has been suggested) and harvest alfalfa of similar forage quality to conventional varieties harvested at the late bud stage? Or should they harvest at the bud stage, resulting in extremely high forage quality, perhaps lower in lignin and NDF than any alfalfa they’ve ever harvested? Delaying all harvests until 25% bloom would in many cases result in one fewer harvest per season, but higher yield per cutting: Alfalfa makes considerable growth between the bud stage and 25% bloom. One fewer harvest would mean lower labor and equipment costs, also less field traffic. This latter result is noteworthy: A three-year University of Wisconsin trial found a yield increase of half a ton of alfalfa per acre in 2nd through 4th cut yield just by increasing mower width from 10 to 13 feet. A wider mower means fewer passes, and
therefore less wheel traffic damage. Another factor favoring delaying harvest until early bloom is that it allows the plants to accumulate more root carbohydrates. Time will tell, but the combination of reduced wheel traffic plus better root nutrient status may be enough to permit at least one more year of productive stand life.

The decision to seed reduced lignin alfalfa is one that should be discussed with your dairy nutrition consultant, especially if you plan on harvesting the forage at the bud stage. There’s a place on Eastern dairy farms for what in the Western U.S. is called “supreme” alfalfa quality—perhaps closest in forage quality to our fall-harvested alfalfa—but you need a plan: Where will you store this forage, what is the analysis, and how will you feed it to take maximum advantage of reduced lignin and the resulting higher digestibility?