



Winter 2010

# DELAWARE DAIRY NEWSLETTER



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## 2011 February Delmarva Dairy Days Thursday, Feb 10, 2011 Hartley Fire Hall, Hartley, DE

- 10 – 10:30 View exhibits and talk to vendors
- 10:30 – 11:10 Managing Your Milk Margin to Improve Dairy Cash Flow  
Tim Beck, M.S., Pennsylvania State University
- 11:10 – 12:00 Matching Genotype to Herd Through Crossbreeding  
Chad Dechow, Ph.D., Pennsylvania State University
- 12:00 – 1:00 Lunch with UD ice cream and visit with vendors
- 1:00 – 1:40 Basics of Managing Herd Reproductive Performance  
Robert Munson, VMD, University of Pennsylvania
- 1:40 – 2:10 Selecting for Feed Efficient Cows  
Chad Dechow, Ph.D., Pennsylvania State University
- 2:10 – 2:40 Update on DE CAFO Regulations  
Larry Towle, Delaware Department of Ag

*Nutrient management credits will be awarded for those staying for the program and listening to the CAFO regulations presentation.*



**RSVP NEEDED FOR LUNCH:** Please contact Susan Truehart Garey by phone (302-730-4000) or email ([truehart@udel.edu](mailto:truehart@udel.edu))

**CREATING THE PHYSICAL ENVIRONMENT FOR TRANSITION COW SUCCESS**

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**ABSTRACT**

Field studies of transition cow management using Transition Cow Index<sup>®</sup> as the outcome variable have shown that housing constraints are the major risk factors for fresh cow health in freestall dairies today. Key factors to improve fresh cow health are provision of sufficient bunk space so that all transition cows can eat simultaneously, minimizing social stress or the need to establish social rank during the prepartum period, provision of soft bedded surfaces for standing and resting, and sizing of stalls and packs to facilitate the motions of lying and rising for large, mature cows. Provision of these conditions allows caregivers to screen for fresh cows that need attention in the most effective way.

**INTRODUCTION**

The phrase widely attributed to the management writer Peter Drucker, “If you can’t measure it, you can’t manage it” seems to have been especially pertinent to the development of our transition cow management advisory programs. Looking back, the development of the measurement tool Transition Cow Index<sup>®</sup> (TCI<sup>®</sup>)<sup>13</sup> has made possible our studies of transition cow management in the world of commercial dairies. It has allowed us to evaluate associations between housing systems and fresh cow health that are not financially possible for research institutions. Prior to our use of TCI<sup>®</sup>, our clinical group would investigate complaints of “too many DA’s, deads, RP’s, etc” using primarily ration analysis techniques. Essentially, we were investigating poorly defined problems using very narrowly focused tools.

Our approach began to change following a field survey using TCI<sup>®</sup> which we conducted in 2005. We surveyed the transition management practices of 50 Wisconsin freestall herds with an average size of approximately 600 cows. The herds represented a stratified random selection of herd average TCI<sup>®</sup> values; meaning that equivalent numbers of herds were selected from each TCI<sup>®</sup> category, i.e., <-1,500, -1,500 to -500, -500 to +500, etc. Another field study of transition cow management practices was conducted in 22 open lot dairies in the Southwest USA in the summer of 2009. From these surveys, a modest number of management practices have emerged as associated with improved herd TCI<sup>®</sup> scores. Knowledge of these key transition management practices has informed our investigation services, our education programs for veterinarians and veterinary students, and an ever-increasing planning service for dairies as they construct new facilities. TCI<sup>®</sup> is available to commercial dairy herds through AgSource DHIA services based in Wisconsin and can be accessed through Dairy One in New York. It is also available in Eastern Canada through Valacta in Quebec.

The key factors associated with improved herd average TCI<sup>®</sup> scores relate to provision of sufficient bunk space so that transition cows can eat simultaneously when fresh feed is delivered, minimizing social stress or the need to establish social rank during the prepartum period, increasing cow comfort with deeply bedded stalls or packs and provision of ample space to lie down, and an effective process to promptly detect fresh cows in need medical attention.

While ration formulations remain a part of our investigation services, variation in dry cow and close-up ration formulations in our survey work has not been associated with herd TCI<sup>®</sup> averages. It would be a mistake to infer that ration formulations do not matter. Rather, it may be that the ration formulation services provided to larger herds are generally of good quality and variation between well formulated transition rations is not a major determinant of overall transition success in our industry today.

**BUNK SPACE**

Sufficient space at the feeding fence for all transition cows to eat simultaneously appears to be the most important determinant of transition cow performance in our current industry. In very practical terms, we are recommending a minimum of 30 in of bunk space per Holstein cow in pre-fresh and post-fresh pens for a 90-min period after fresh feed is delivered and after every milking. A discussion of the studies that support this recommendation has been presented previously<sup>14</sup>.

To determine feeding space/cow, it is important to focus on length of bunk as opposed to counting self-locking stanchions or headlocks. Headlocks come in a number of widths including 24, 27, and 30 inch intervals between each unit. Our video studies show that lactating Holstein cows fill a row of 24 in headlocks to a maximum of 80 % at peak feeding periods. This 80% maximal fill

rate occurred in two and three row pens, each with various stall stocking densities, suggesting that the finding was independent of the number of cows per headlock. Converting these numbers, it suggests that lactating Holstein cows will voluntarily fill a bunk at a spacing of one cow per 30 inches. It is likely that pregnant prepartum cows would take even more space than lactating cows.

These recommendations for 30 in of space assume that the pens are equipped with lockups or other vertical dividers between feeding spaces. If the cows are fed at a post-and-rail feeder, additional space should be provided as dominant cows appear to clear subordinates sooner in these situations<sup>8</sup>.

While we focus the most attention on bunk space in the close-up and fresh pens, the actual number of cows in these pens usually changes every day. If cows are transferred into the close up pen on a weekly basis, and if cows move to calving pens on a daily basis, there will be wide weekly swings in the number of cows in the pen. The opposite dynamics characterize the fresh pens. In addition, there will usually be seasonal changes in stocking pressure that track seasonal infertility and recovery by 10 months. Because of these pen dynamics, it is more useful to focus on the longer term capacity of the pens.

The traditional approach to sizing close up and fresh pens is to calculate the average number of calvings per week by dividing the total number of calvings in the past year by 52 weeks per year. Then the average number of calvings/wk is multiplied by the target number of weeks in the pen. For example, if a dairy has an average of 20 calvings per week and the planned duration of stay in the close up pen is 3 weeks, most planning manuals suggest that the close up pen should be designed to house 60 cows. By definition, pens designed in this manner are overstocked half of the time.

We prefer to build special needs pens to accommodate the surges in numbers of special needs cows. Based upon a review of a number of Midwestern herd records, we have recommended sizing close-up and fresh pens for 140% of the average number of calvings. In the example from the paragraph above, we would recommend provision of not 60, but 84 stalls in the pre-fresh pen with an available bunk that is 240 feet in length. Sizing these pens on this basis will mean that these pens are overstocked less than 10% of the time. There are also times when pens sized on this basis appear to be substantially understocked, or as some would say, "grossly overbuilt". Our estimations of the impact of this practice suggest that this makes economic sense. Each stall and headlock in a pre-fresh pen has an impact on the start of somewhere between 10 to 15 lactations each year. Because of the multiplier effect on the start of the lactation of so many cows, it is critical that these facilities are excellent and available to all cows.

### **PEN MOVES AND SOCIAL STRESS VERSUS STABLE SOCIAL GROUPS**

Each pen move requires that a cow familiarize herself with the surroundings, as well movement into a new social group also creates stress as the cow establishes rank within the group<sup>9</sup>. The first 2 days after entry into a new social group are characterized by a dramatic increase in the number of agonistic interactions, most of them physical<sup>11</sup>. If no additional new cows enter the pen, the group becomes relatively stable. More recent work with mid-lactation cows has shown reduced time spent eating, increased feed evictions, and reduced milk yield following a pen move<sup>19</sup>. Minimizing the number of regroupings through the transition period is consistent with successful transition programs. In most situations, steps to reduce any moves will result in improved transition performance.

A concept of a *social turmoil profile* of a pen has been described<sup>14</sup>. In pens where cows enter at intermittent intervals, like a week or more, extended stays in such pens are considered more desirable than in pens with entries and departures every day. Daily entry pens are considered to be in constant social turmoil and every effort should be made to minimize the time that prepartum cows spend in these pens.

Cows are social animals. Isolation from the herd creates stress for a cow and separating a single cow into a separate calving pen for more than a couple of days appears to be a practice with high risks for fresh cow health.

#### ***Dry and Close-Up Pens***

The traditional close-up pen is based upon cows entering the pen approximately 3 weeks prior to due date. For reasons of convenience, cows are separated from the far-day pen and moved to the close-up pen once or twice each week. In some systems, the cows deliver their calves in the close up pen, while in other systems they are removed to calving pens at various times relative to delivery.

Studies on the effect of the number of cows moved at one time have been conducted. Generally, movement of single animals should be avoided as it is believed that familiarity and social bonds among 3 to 5 moved animals may reduce the social stress of integrating within a larger group<sup>17</sup>. Sowerby and Polan did not find significant production differences between groups where between 2 and 14% of the cows were transferred at one time between lactating groups<sup>16</sup>. For reasons of both increased numbers of transferred cows and a decreased proportion of high turmoil days, a weekly move policy would appear to be preferable to more frequent entries.

Regardless of the frequency of new cow additions in our traditional close-up pen, each cow remains in a dynamic social system for a period of several weeks before calving. New arrivals tend to be involved in more agonistic interactions than the current residents of the pen. Brakel and Leis showed that during the first day after regrouping, the average moved cow was involved approximately double the rate agonistic interactions of the resident cows in the pen<sup>2</sup>. Moved cows will tend to maintain their rank relative to the other cows that were moved<sup>15</sup>, but occupy a low rank with respect to the resident cows, even first-lactation, that already occupy the pen. However, the situation is sometimes more complex. Hook observed a complete reversal of the social rank of a group of six heifers with the removal of the high rank individual and the simultaneous introduction of a new heifer<sup>10</sup>.

As we began applying these concepts to transition cow management, we proposed that the optimal transition cow pens would be based upon an *all-in* pen where a cohort of cows due to calve within a short period of time, such as a 7 to 14 day window, are assembled with no further additions through the calving process<sup>4,14</sup>. The stable social group could be assembled at the time of the traditional close-up period of 3 weeks prior to calving date, or the groups could be assembled at dry off. In either system, social rank would be established in the first days after the group is assembled, but would be followed by relatively less turmoil in the weeks that precede calving. Depending on the planned duration of the dry period, there could be 4 or more separate cohorts of dry cows in the series of stable group pens. The usual policy would be to periodically move entire pens of cohorts intact into the next pen in order to keep the cows near due date in a location proximal to the calf delivery facilities.

Establishment of stable groups at the time of dry off appears to bring with it several benefits. First, the group is established long before calving date and even cows that deliver their calf a week or two prematurely are well established in a stable situation. Second, it eliminates the additional lockup of dry cows and removal of close up cows from that group. Third, monitoring dry matter intakes of close-up pens becomes more meaningful when the cows within each pen are stable in numbers and stage of pregnancy.

In practical terms, even though there is an attempt to develop stable groups at dry off, it is typical to need to make some modest number of transfers between pens. Individual cows may be dried off early or late and may need to be transferred into a pen with cohorts more likely to calve at a similar time. Likewise, as the cows deliver and are transferred out to the fresh cow pen, there will ultimately be a situation where there is a single cows remaining. It is generally viewed as preferable to merge them with the next cohort of cows when two remain in the pen.

### Calving Pens

Calving pens can refer to either a pen to which a cow is moved hours before delivering her calf or it could be a close-up pen where cows enter several weeks before their anticipated calving date and deliver the calf within the pen. If the calving pen has a stable social structure (no additions), extended stays are fine. If new cows are continually being added, we recommend that the duration of stay be limited to 48 hr maximum. Clinical data from field investigations by the Food Animal Production Medicine group at the University of Wisconsin show dramatic increases in ketosis and displaced abomasums and early lactation culling of cows that stay 3-10 d in daily-entry group calving pens<sup>14</sup>. When cows are moved to calving pens on a daily basis, they should be selected carefully so that minimal numbers spend more than 48 hr in these high turmoil pens.

It has become common to move cows to calving pens when the feet or head of the calf are showing. Moving cows to calving pens once calving has begun, commonly called "just in time" calving, effectively minimizes the time in high turmoil pens, but presents a new set of challenges. First, it requires round-the-clock labor to check and move cows. Freestall pens can be designed to facilitate this practice with the construction of two-row head-to-tail arrangements of the stall rows. With the tails of all cows visible from the central feed alley, the observer can monitor each cow without walking through and disrupting the pen. Second, workers must be monitored carefully in that they should not move cows into calving pens too early. In a report on moving cows when parturition was imminent<sup>3</sup>, cows that were moved when in labor but with only mucus showing had 2.5 times the rate of stillbirths as cows that were moved when the calf's feet or head were showing. When the close-up cows are in freestalls, there is a tendency of laborers to move cows into calving pens too early. By moving cows into the pens early, fewer calves are born into the alleys and workers can avoid soiling their clothing when picking up slurry-covered calves. This tension between worker convenience and calf health needs to be monitored and managed in these "just in time" calving systems.

Isolation pens, i.e., box stalls would appear to minimize social turmoil, but cows are social animals and separation from the herd is usually a stressful experience. If cows are moved to individual box stalls for calving, the duration of stay should be limited to a matter of a few hours.

### SURFACE CUSHION IN STALLS, PACKS, AND UNDER SHADES

A loose, deeply bedded surface has emerged in our field studies as a major factor for improving fresh cow TCI<sup>®</sup> scores. In freestall herds, sand based stalls were associated with more than a 1,000 lb TCI<sup>®</sup> advantage over herds with mattress freestalls.

Similarly, depth of loose bedding under shades emerged as a risk factor affecting herd average TCI<sup>®</sup> scores in open lot dairies.

There is increasing evidence that locomotion scores increase for a substantial proportion of transition cows<sup>20</sup> and physiological mechanisms have been proposed where the same physiological changes that are associated with the loosening of the pelvis to accommodate parturition also relax the suspensory apparatus of the digit in the hoof<sup>18</sup>. The study of sand and mattress freestalls by Cook et al<sup>5</sup> showed that cows with elevated locomotion scores change their behavior on mattress stalls, but not on sand, may explain the substantial improvement in fresh cow performance on sand surfaces.

Any deep, loose surface will be an improvement over a hard surface. Mattresses covered with modest quantities of shavings or other materials are viewed as average, and any stall surface such as concrete or other firm packed materials covered with modest bedding should be considered a high risk to successful transitions.

### AMPLE SIZED FREESTALLS, PACKS, AND SHADES

A deeply bedded pack is the probably the preferred housing for close-up cows in confinement housing. The guideline of 100 sq ft of space/cow<sup>1</sup> includes the bedded area only and assumes that cows have access to an external feeding alley or outside lot. If the feeding area is continuous with the bedded pack, the space should provide a minimum of 120 sq ft/cow with good bedding covering most of the area. The pack should be sized to accommodate surges in cow numbers as discussed in the section on bunk space above.

Prepartum freestalls, in particular, need to accommodate the ample dimensions of pregnant cows and allow for some clumsiness in their rising and lying motions. Stalls for prepartum Holsteins and Jerseys should be at least 50 and 45 in wide respectively<sup>6</sup>. Length is the distance between the outer corner of the rear curb to the point where the stall surface touches the brisket locator. If there is no brisket locator, the total stall length is the stall resting length. This distance should be greater than 70 and 63 in for Holstein and Jersey cows respectively. Appropriate dimensions have been developed for cows of other breeds and various sizes<sup>6,12</sup>.

Evaluating the potential for *lunge, bob, and rise* should reflect assessments of 3 separate items in a freestall: a brisket locator that does not restrict rising motions including the forward swing of the front foot, freedom from impediments to the forward lunge of the head and shoulder, absence of *bob* zone obstructions, and the neck rail being sufficiently high and forward<sup>6,12</sup>. For a stall to be considered low risk for Holstein cows, the total stall length should be at least 9 ft long with no obstructions to forward lunge and bob. If the stall is less than 9 ft, but the lower side rail is 11 in above the stall bed or less, it should allow side lunging and is considered an average risk for transition cows. If the stall is less than 8 ft and has obstructions to side lunging, such as lower divider rails greater than 13 in above the stall bed, the stalls present major risks to successful transition performance. Finally, the neck rail should be approximately 48-50 in above the stall surface.

In open lot dairies, transition cow facilities should provide at least 45 square feet of shade per cow with loose bedding at least 3 inches deep below the shade.

### EFFECTIVE SCREENING PROGRAM FOR COWS NEEDING ATTENTION

While difficult to assess, the primary determinant of the fresh cow screening and treatment program is the quality of the people and how much they care for the cows. Facilities that allow easy restraint without exciting the cows is also critical to these programs.

The optimal screening programs appear to use some form of appetite assessment. The practices of the herdspeople of the elite transition programs in our survey study were remarkably similar: delivery of fresh TMR while fresh cows were being milked, palpation of udders for fullness while being milked, observation of cow demeanor as the cows returned to the pen, i.e., does she go to feedbunk or does she lie down, and an assessment of appetite and attitude. Beyond process, the herdspeople in the elite herds knew and cared about the fresh cows under their watch. Effective screening requires both special people and facilities.

Back to the bunk space issue, it requires sufficient feeding space for all cows to eat simultaneously. Cows that do not lock-up, or cows that lock-up with suppressed appetite or signs of depression were examined. Other examination procedures including rectal temperature, observations for vaginal discharge, ketosis, displaced abomasum, lung sounds, etc., were conducted when primary assessments indicated further evaluation.

While formal screening programs in lockups for fresh cows are a desirable practice, the procedure needs to be efficient and not interfere significantly with the daily time-budget of the fresh cows. Screening procedures that lock cows up for a period of 1 hr or less/d are considered optimal. While cows are quite capable of compensating for a 1-2 hr change in routine, if lock-up is 1

prolonged and in association with other stressors, such as overstocking, then the ability of the cow to compensate and *catch-up* on lying time may be exceeded. Cooper et al. showed that when cows were deprived of lying for 2-4 h/d, they only managed to recover approximately 40 % of the lost lying time by 40 hr after the deprivation<sup>7</sup>. Extended lockup time adds substantially to the stresses of transition.

The location of the screening procedures has a substantial impact on the time constraints. If the cows have access to feed while being examined, feeding and the screening can proceed almost simultaneously. Screening time at a palpation rail, for example, must be weighted as riskier than equivalent time in lockups over feed.

This antagonism between holding time and the thoroughness of the screening procedure puts some severe constraints on the fresh pen.

#### DISCLAIMER

Obviously, this paper does not provide a comprehensive listing of risk factors for transition cows. However, the risk factors presented here are considered to be common problems in today's intensively managed dairies and virtually all dairies will realize improved fresh cow health if they correct deficits in the areas discussed in this paper.

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## Update on the UD Creamery



The UDairy Creamery is a student-centered, faculty supported enterprise of the UD College of Agriculture & Natural Resources. The Creamery is run by a student management team, consisting of CANR students Jake Hunt (Assistant Manager), Rebecca Sheahan (Business Manager), Amanda Prudente (Dairy/Food Science Manager), and Rachael Dubinsky (Sustainability Coordinator/Communications Manager). The students receive year-long paid internships to lead all aspects of Creamery management, with the support of several CANR faculty and staff. Our ice cream is made from milk produced at the 100-cow CANR dairy, located on the CANR Newark Farm, in cooperation with Hy-Point Dairy in Wilmington, Delaware and Byrne Dairy in New York. We began serious efforts to launch the UDairy Creamery in 2008, based on a business plan developed by CANR students from the Department

of Food and Resource Economics. For the past two years, the UDairy Creamery has been selling ice cream at all major UD events, such as Ag Day, Coast Day, Forum and Reunion Weekend, UD basketball and football games, Admissions programs such as Discovery Days and Decision Days and at Newark Community Days and the Taste of Newark.



Our goal has always been to build a Creamery facility where our student team could make UDairy ice cream on site and this will become a reality by early spring of 2011 as we just broke ground on the new UDairy Creamery facility the first week of November, 2010. The Creamery will be located directly behind CANR's main building (Townsend Hall) and adjacent to the Rust Ice Arena. The Creamery will be an integral part of our college's teaching program, particularly for students interested in food science, dairy science, agribusiness management, and marketing. It will also play an important role in our extension outreach programs related to sustainable agriculture and will provide some research opportunities for our undergraduate students. We are now in the process of hiring a full-time Creamery Manager to work with our student team on a day-to-day basis in their efforts to make the Creamery a successful UD enterprise.



We have spent nearly a year planning the Creamery, with the assistance of many friends and partners, including other University creameries such as those at Penn State and the University of Maryland. We hope to have it fully open for business by Ag Day in late April of 2011.

The Creamery will contain an ice cream manufacturing area where our student team will make ice cream and package into pints for sale throughout the UD Campus. We will also be working with UD Dining Services to sell ice cream scoops at many campus venues. It will also have a small storefront where ice cream can be purchased as

scoops, pints, half-gallons, and even 3-gallon containers for large parties. Coffee, sodas, water, and other drinks will also be sold. All landscaping at the Creamery will follow the principles of sustainable landscape design and will be done by students and faculty from our CANR Landscape Design program and the UD Botanic Gardens. In the future, we will also sell other items produced on the CANR farm, such as wool blankets made from our sheep and honey from our apiary.

## EFFECT OF TIME OF STORAGE ON CHANGES IN NUTRIENT COMPOSITION AND VALUE OF SILAGES

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### INTRODUCTION

(A short note was presented on this subject to you in a past issue. This is an expanded review on this subject and was presented at the 2010 Cornell Nutrition Conference.)

The primary goal of ensiling forages has been to conserve the maximum amount of original dry matter, nutrients and energy in the crop for feeding at a later time. There are four general phases of silage fermentation: 1) the initial aerobic phase, 2) the active fermentation phase, 3) the stable phase and 4) the feedout phase (Barnett (1954). In brief, the production of organic acids and the attainment of a low pH under anaerobic conditions result in the end product inhibition of plant and microbial processes to attain the "stable phase". Without silage additives, the general consensus has been that silage fermentation cannot make forage quality better than what was in the original crop.

### CHANGES IN FERMENTATION END PRODUCTS AND MICROBIAL POPULATIONS

A period of 3 to 4 weeks has generally been accepted as adequate time for active silage fermentations to cease and reach a stable phase, but a variety of factors may affect this. However, Ward and de Ondarza (2008) suggested that based on changes in silage fermentation samples submitted to Cumberland Valley Analytical, corn silage requires at least four months for a full fermentation.

Typically, silages with high moisture content ferment more rapidly than those with low moisture contents because in the later, the availability of metabolic water for microbial growth decreases as moisture declines (Whiter and Kung, 2001). Extremely cold temperatures at harvest may cause a slow and prolonged fermentation period. In fact, Periera et al. (2009) showed that alfalfa forage can be frozen for several months, and then thawed and the material will then ensile normally. During the classical stable phase, many microbes are in a dormant state but still culturable. For example, lactic acid bacteria have been detected in relatively high numbers (> 5-6 log cfu/g of wet silage) in silages stored for up to a year (unpublished data, University of Delaware). Schmidt et al. (2008) reported that lactic acid bacteria in untreated alfalfa silage peaked between days 5 and 45 (> 9 log cfu/g) of ensiling and was still greater than 6-log cfu/g after 180 d of ensiling. Yeasts can withstand very low pH in silages and Kleinschmit et al. (2006) were able to enumerate them from corn silage after a year of storage. In samples of corn silage that had been stored under anaerobic conditions for 5 years we could culture yeasts in 1 of 9 and lactic acid bacteria in 2 of 9 corn silage samples (unpublished data, University of Delaware). Spores of clostridia and bacilli can also persist for prolonged periods in silages.

Changes in fermentation end products even after several months of ensiling suggest that microbial activity persists even when the pH is low. For example, some strains of *Lactobacillus plantarum* have the capability of converting lactic to acetic acid in the absence of fermentable sugars via a pyruvate-formate lyase system (Lindgren et al., 1990). The result of this is a silage with a slightly higher pH, lower lactic acid concentration and higher acetic acid concentration at a later date when compared to an analysis of the same silage from an earlier date. *Lactobacillus buchneri* also appears to be fairly active for long period of time in corn silage and probably also contributes to this finding. Under anaerobic conditions and low pH, this organism is able to convert lactic acid to acetic acid, ethanol and 1,2 propanediol (Oude-Elferink et al., 2001). Kleinschmit et al. (2006) reported on changes in the fermentation end products of corn silage ensiled in mini silos for up to 361 d. In that study, silage was untreated or treated with a combination of *L. buchneri* and *Pediococcus pentosaceus*. Across both treatments the concentrations of lactic acid decreased by about 15% between day 14 and a year of ensiling. Both treatments showed more than an 80% increase in acetic acid over the same period of time. However, the major increase in acetic acid in untreated silage occurred between 282 and 361 days whereas this increase was observed as early as day 56 for silage treated with *L. buchneri*. Evidence suggesting that the change in concentration in acetic acid for both silages was most likely due to *L. buchneri* (either natural or added populations) was the fact that 1,2 propanediol was only detected in untreated silage at day 361 whereas substantial amounts of this compound were detected in treated silages as early as 42 d of ensiling. Using a quantitative-polymerase chain reaction method, Schmidt et al. (2009) showed large increases in the numbers of *L. buchneri* in treated alfalfa silage with smaller increases (from the natural epiphytic population) in untreated forage. The population of *L. buchneri* in treated silage was greater than 7 log cfu/g of wet silage after 180 d of ensiling documenting that this organism is relatively acid tolerant and can survive for long periods of time in fermented silage.

### CHANGES IN NITROGENOUS COMPOUNDS

There are considerable changes in the nitrogenous fractions of forages during ensiling. Proteases from plant sources are quickly inactivated with a drop in pH, thus their contribution to nitrogenous changes during prolonged storage is doubtful. However, microbial proteases appear to be relatively active throughout a prolonged period of fermentation. Schaadt and Johnson (1969) reported a loss of true protein in corn silage presumably due to proteolysis up to 180 d of ensiling but it was unclear when or if there was a plateau for proteolysis because there was a large gap between the day 8 and 180 sampling times. Filya (2002) reported increasing amounts of NH<sub>3</sub>-N in corn and sorghum silages through 90 d of ensiling. Kleinschmit et al. (2006) reported a steady increase in NH<sub>3</sub>-N in corn silage through 361 d of ensiling without reaching a plateau. Newbold et al. (2006) ensiled 15 corn silages and reported increasing amounts of degradable CP with time through 10 months of sampling. Changes in the amino acid content of silages with prolonged storage have not been quantified to our knowledge.

### CHANGES IN CARBOHYDRATE FRACTIONS OF SILAGES

Ensiling also causes a number of changes in the carbohydrate fraction of forages. Water-soluble carbohydrates are used by lactic acid bacteria in the production of organic acids. Morrison (1979) showed that the core lignin concentration of forage did



not change and cellulose decreased up to 5% during ensiling after 150 d of storage. However, there were substantial decreases in hemicellulose, up to 10-20%, which may explain the acidic conditions and microbial activity in the silage. Forage treated with exogenous acid additives lost the most carbohydrates during ensiling. Yahaya et al. (2001) confirmed that considerable loss of the hemicellulose and pectin fractions occurs in alfalfa and orchard grass silage between fresh forage and material ensiled. That study reported that hemicellulose digestion decreased with time of ensiling for both forages whereas digestion of cellulose actually increased with time of storage for alfalfa. One limitation of that study was that sampling only occurred up to 56 d in the silo. We are aware of only a few studies where the effects of prolonged ensiling (>150 d) on the digestibility of fiber in silages have been reported. Hallada et al. (2008) showed a steady increase in in situ NDF-D of corn silages of about 1.2% units per month between samples from day 1 through 330 d of ensiling without appearing to reach a plateau. In contrast, we (Der Bedrosian

et al., 2010) found that time of ensiling did not affect the in vitro NDF-D of two corn silage hybrids between 45 and 315 d of ensiling. Cone et al. (2008) also reported that length of storage (up to 180 d) did not affect the digestibility of cell walls as evaluated by in vitro gas production. The reasons for the discrepancies between studies is unknown but may be related to the methods used for assessing fiber digestion, the silage hybrids used and other silo management factors.

Prolonged ensiling has been shown to improve the digestibility of DM and starch in corn crops. Benton et al. (2005) ensiled HMC for up to 298 d at various moistures and sampled the material every month. In all cases, in situ digestion of DM increased as days of storage increased. Of particular note was the fact that the increase in digestion was greater for HMC with 30% (less mature) than 24% (more mature) moisture content. Hoffman et al. (2010a) also reported that the fractional degradation (via in vitro gas production) of HMC increased moderately with time in the silo. In corn silage, European researchers reported increases in in sacco starch digestion of corn silages (Newbold et al., 2006) and Hallada et al. (2008) reported improvements in laboratory estimates of total tract starch digestion with increasing time in the silo as well. Recently, our group (Der Bedrosian et al., 2010) reported increased in vitro digestion of starch in normal and BMR corn silage hybrids through 270 d of storage. In contrast, Cone et al. (2008) reported that increasing the time of storage did not affect estimates of starch digestion when evaluated through an in vitro gas production system. Increased starch digestion with prolonged storage was hypothesized to be due to solubilization of prolamins by acids and alcohols, but recent evidence suggests that proteolytic activity may explain this phenomena (Hoffman et al., 2010b). The protein-starch matrix in starches is somewhat analogous to the lignin-fiber matrix in forages, thus degradation of prolamins in the matrix improves the availability of starch.

### CHANGES IN LIPID COMPOSITION

The ensiling process can affect the lipid composition of forages. Van Ranst et al. (2009) suggested that lipolysis in the silo was greater in silages that had undergone extensive fermentation. To our knowledge, a change in the lipid composition of forages

due to prolonged storage in the silo has not been studied. A joint research effort between the University of Delaware and Michigan State University (A. Lock) is currently addressing this question in corn silage.

### PRACTICAL IMPLICATIONS AND QUESTIONS

What do these findings mean for the average dairy farmer?

Although increasing the storage time of corn silage and HMC appears to improve the rumen availability of starch, not all producers have the capability to increase inventory to achieve this because of a limited land base and (or) fixed silo inventory. The added cost of carry over has also not been thoroughly evaluated. Furthermore, when modeling forage changes in the silo, Buckmaster et al. (1989) reported that emptying a silo in 120 d vs. 360 d reduced DM loss by 6%. They concluded that increasing time in the silo results in greater DM loss because of infiltration of air in to the mass. Thus, this factor should be considered when making a decision about storing silage for longer periods of time.



For those producers that can store silage for longer periods of time before feeding, extra precautions must be taken in silos where plastic is used to maintain anaerobic conditions (bunks, pile, and bags). Chances of damage to the plastic increase with time of exposure to UV radiation, animals and general degradation of the plastic. Because silo plastic is permeable to oxygen, prolonged storage ultimately increases the exposure of surface silage to more air. Prolonged storage also means that silages will be fed in warmer weather and be prone to more aerobic deterioration. The need for excellent silo management in terms of correct moisture, chop length, density

and sealing will be critical to maintaining silage quality. Use of plastic with low oxygen permeability and the use of additives to improve aerobic stability (e.g. *Lactobacillus buchneri*) should be considered.

Changes in starch digestion with prolonged storage may explain two phenomena that are commonly observed with lactating cows. First, it is common to hear reports of cows dropping in milk production when switched from “last season’s” corn silage to freshly ensiled corn. Some of this “slump” may be attributable to the consumption of large quantities of unfermented sugars, but it may also be due to the fact that freshly ensiled corn silage is much lower in starch digestion than silage fermented for a longer period of time. Second, it is also common to receive reports of cows with laminitis and low fat tests in the spring. This may be a result of the increased availability of starch in corn silage and HMC. Thus, although prolonged storage of silage improves the digestibility of starch, many may find it difficult to adjust diets to compensate for these highly digestible feeds. If this is the case, one suggestion might be to process corn silage less aggressively and grind HMC more coarsely for those feeds that will be stored for longer than 8-9 months.

Because HMC and corn silage stored the longest will most likely be highly digestible, crops harvested at a mature stage of development might be best fed later in the year because proteases would have more time to improve their value. In contrast, producers may consider feeding the most immature corn and corn silage early in the season as these feeds would have higher digestibility than more mature forages at initial harvest.

### CONCLUSIONS

To date, there is mounting evidence that prolonged storage time of corn silage improves starch digestion and increases protein solubility. These factors should be taken into consideration when balancing diets for dairy cows. In addition, more research is warranted in this area because some management factors may affect the degree of changes one might obtain with prolonged storage. For example, the effects of prolonged storage on poorly processed corn may have less of an effect because there would be less surface area in contact with microbial proteases. Packing density may have an effect on effects of storage time because of pressure and distribution of fluids throughout the mass. We (University of Delaware) are currently investigating the effects of prolonged storage on alfalfa silage. Future studies in this area will help us to better utilize silages in diets for ruminants.

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