

DAIRY DAY 2000

Report of Progress 861

2000 Dairy Day Program

10:00 a.m./3:00 p.m. Registration

10:25 a.m./3:25 p.m. Welcome

Lunch/Dinner Courtesy of the Kansas Dairy Association (KDA)

Topics to be presented:

“Milk Quality from the Processor’s Point of View” Dr. Karen Schmidt

“Mastitis Management-Effective Methods to Reduce Somatic Cell Counts” Dr. Mike Brouk

“Important Silage Practices Often Overlooked” Dr. Keith Bolsen

“Update of Nutritional Research at K-State” Dr. John Shirley

2:30 p.m./8:00 p.m. Adjourn

Locations:

Thursday	November 9	3:00-8:00 p.m.	Garden City 4-H Building
Wednesday	November 15	10:00 a.m.-2:30 p.m.	Seneca Valentino’s
Thursday	November 16	10:00 a.m.-2:30 p.m.	Whiteside Amish Community Building
Friday	November 17	10:00 a.m.-2:30 p.m.	Emporia American Legion Post

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FOREWORD

Comparison of Heart of America Cows with Kansas Cows - 1999

Item	HOA	KS
No. of herds	1,184	362
No. of cows/herd	170	101
Milk, lb	19,035	19,476
Fat, lb	693	704
Protein, lb	621	633
IOFC*, \$	1,651	1,559
Milk price, \$	13.98	13.74

*IOFC = income over feed costs

Members of the Dairy Commodity Group of the Department of Animal Sciences and Industry are pleased to present this Report of Progress, 2000. Dairying continues to be a viable business and contributes significantly to the total agricultural economy of Kansas. Wide variation exists in the productivity per cow, as indicated by the production testing program (Heart of America Dairy Herd Improvement Association [DHIA]). The Heart of America DHIA began business on January 1, 1995, by combining three labs into one. More than 137,000 cows were enrolled in the DHI program from Kansas, Nebraska, Oklahoma, Arkansas, North Dakota, and South Dakota beginning January 1, 2000. A comparison of Kansas DHIA cows with all those in the Heart of America DHIA program for 1999 is illustrated in the table above.

Most of this success occurs because of better management of what is measured in monthly DHI records. In addition, use of superior, proven sires in artificial insemination (AI) programs shows average predicted transmitting

ability (PTA) for milk of all Holstein AI bulls in service (August, 2000) to be +1,390 lb. Continued emphasis should be placed on furthering the DHI program and encouraging use of its records in making management decisions.

The excellent functioning of the Dairy Teaching and Research Center (DTRC) is due to the special dedication of our staff. **Appreciation is expressed to Richard K. Scoby, who recently retired after 13 years of dedicated service as manager of the DTRC.** We acknowledge our current DTRC staff for their dedication: Michael V. Scheffel (Manager); Donald L. Thiemann; Daniel J. Umsheid; William P. Jackson; Charlotte Boger; Lesa Reves; Eric Friedrichs; Robert Reves; and Greg Steer. Special thanks are given to Betty A. Hensley and Cheryl K. Armendariz and a host of graduate and undergraduate students for their technical assistance in our laboratories and at the DTRC.

Each dollar spent for research yields a 30 to 50% return in practical application. Research is not only tedious and painstakingly slow but expensive. Those interested in supporting dairy research are encouraged to consider participation in the Livestock and Meat Industry Foundation (LMIF), a philanthropic organization dedicated to furthering academic and research pursuits by the Department of Animal Sciences and Industry (more details about the LMIF are found at the end of this publication).

J. S. Stevenson, Editor
2000 Dairy Day Report of Progress

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RAW MILK QUALITY: THE PROCESSOR'S POINT OF VIEW

K. A. Schmidt

Summary

Raw milk quality is important to the processor for many reasons, this quality can be assessed by several different tests. Quality tests are used to ensure that the raw milk meets legal USDA standards as well as some of the individual requirements of the processor. Although some quality tests can be done in a matter of minutes, others require up to several days to complete. Because milk quality deteriorates relatively quickly, it is important to concentrate on those tests that provide the greatest amount of information in the shortest time. This information then is extrapolated to assess the "actual raw milk quality". After all, the quality of milk does not improve with time; thus, if the starting materials are substandard, the final products will be less than substandard. Generally, raw milk quality is assessed by type and number of microbes, milk composition, presence of contaminants, and current (and perhaps previous) temperature.

(Key Words: Raw Milk, Quality, Incoming Tests.)

Microorganisms

In raw milk, the assumption is that pathogenic microbes (those that cause disease) will be present. However, in the U.S., most processors do not assess the type and number of a specific pathogen(s) in raw milk. Testing for specific microorganisms can be both time-consuming and inefficient. However, the type and number of microbes will affect the quality of the product. Microbes differ in their temperature and nutrient requirements for growth. For many years, lactic acid bacteria (LAB) were of great concern to

producers and processors. As LAB grow in milk, they utilize lactose, subsequently producing lactic acid, which causes a decrease in pH. The milk then sours and as a final result, it is unfit for fluid, cultured, or fermented products.

Over time, refrigeration has been mandated at producer, in-transit, and processor locations, because maintaining low temperatures (<45°F) minimizes the growth of LAB. Psychrotrophic bacteria, which can grow at low temperatures, have become the predominant microbes in raw milk today. These bacteria may not grow quickly at refrigeration temperatures, but they can utilize the milk components as nutrients and produce enzymes that further degrade fat, lactose, and proteins. Degradation of these milk components leads to off-flavors and odors that may cause the raw milk to be unfit for processing or consumption as fluid milk. Depending on the reactions, this raw milk also may not be suitable for other dairy products. For instance, if the casein protein has been degraded, cheese yields can be reduced drastically and the off-flavors in the milk may be carried through to the final product. In addition, rancid or oxidized milk (the result of fat degradation) is unsuitable for ice cream or butter, because the fat-derived off-flavors carry through to the final product. Another issue is that as milk components are degraded, their functionality changes and the ability to manufacture some products may be compromised.

Pasteurization generally reduces the total number of microbes in raw milk. A higher number of bacteria implies that more reactions have occurred and more enzymes (which may not be inactivated during pas-

teurization) will be present in the pasteurized milk. This presence of more bacteria decreases the shelf life of the product as well as its quality. Shelf life usually depends on the number of spoilage microorganisms present in the milk. Once the number of bacteria reaches a certain level, the milk is considered "unsaleable".

Typical microbial testing done at the processing plant on raw milk includes coliform, preliminary incubation (PI), and standard plate count (SPC) tests. These three tests measure different aspects of the microbial quality and require 24 to 72 hr to perform. The coliform test indicates the degree of cleanliness of the raw milk. Greater coliform counts are interpreted as potential fecal contamination of the raw milk. Although no standard exists for maximum allowable coliform counts in raw milk, milk processors want raw milk with the lowest possible number of coliforms. The SPC enumerates the number of aerobic bacteria in the sample. Legally, maximum limits for the bacteria counts are allowed in fluid milk, and these limits vary depending upon whether the milk is from a single source or is commingled. The PI testing is used as an indication of the keeping quality of the milk. Often, individual plants set their own guidelines and test conditions to define acceptable limits for the PI test.

Composition

Legally, according to the Pasteurized Milk Ordinance, milk is defined by its fat and solids-not-fat contents. The public buys and consumes fluid milk (and other dairy products) based on fat content; thus, the fat and total solids contents of the incoming raw milk play key roles in dairy foods marketing.

Milk fat imparts desired and unique functionality to products such as milk, ice cream, butter, and certain cheeses. Not only is the quantity of fat important for these products, but the integrity of the fat (little to no chemical reactions such as oxidation or lipolysis) must be high, so that the final products have acceptable flavors, odors, and textures. Milk protein, in particular the

quantity and integrity of casein, influences cheese yields. Lactose contributes sweetness and imparts viscosity to fluid milk and other fluid dairy foods. Physically, lactose and minerals depress the freezing point of milk; thus, as their concentrations decrease, the freezing point increases. Many processors and governmental agencies use this relationship to determine if water has been added to the raw or fluid milk product.

In most large plants today, the compositional analyses can be done relatively quickly with the use of infrared technology. This technology provides rapid results for composition of protein, lactose, and total solids, depending on the sophistication of the instrumentation. To determine if water was added to the milk, the freezing point is measured. This also is a rapid test that is fairly accurate. Both types of instrumentation can produce results within 5 to 10 min depending on the instrumentation itself, operator experience, and calibration status.

Titrate acidity (TA) and pH are two other chemical measurements that may be utilized to monitor the raw milk quality. In both cases, the acidity of the milk is measured. Generally a "high acid" milk sample indicates that microbial activity is high. These two methods measure different chemical compounds within the milk, so their interpretations are different. Both methods are easy and relatively inexpensive to perform, provided the equipment is available. In the U.S., high-quality raw milk will fall within a narrow range of pH and TA levels. Thus, deviations from these narrow limits indicate that raw milk quality has been compromised.

Contaminants

In recent years, the main raw milk contaminants of concern are antibiotics, toxins, and pesticide residues. All U.S. processors must test for the presence of antibiotic residue in raw milk prior to receiving the milk into the plant. When antibiotic-contaminated milk is in the general milk supply, those individuals who are allergic to a specific antibiotic may have an allergic reaction if

they consume the milk. To date, pasteurization does not inactivate antibiotics; thus, they pass from the raw milk into the final product. Over the years, reports of serious illness and several deaths have been associated with consumption of milk that contained antibiotic residues. Federal law mandates that all incoming raw milk is tested for the presence of antibiotics. Most facilities have an approved "quick" test procedure and equipment for detection of a certain type of antibiotics. These tests can take from 10 to 40 min depending on the equipment model and operator's experience.

Aflatoxin is a concern for all milk processors and producers. When a cow consumes tainted feed, aflatoxin may be transferred into her milk. Aflatoxin is a powerful neurotoxin that can harm humans. Recently, reports of other contaminants in dairy products, such as dioxin, have surfaced. Residues from pesticide and other treatments used for crop, land, or water management can be ingested by cows and eventually can transfer into the milk. All of these unwanted compounds can be dangerous for the consuming public.

Most processing plants do not have the capability to test for specific toxins in the raw milk supply. This testing may be done at the main headquarters' laboratory, or the dairy processing company may contract an outside, independent, testing laboratory to do these analyses. Testing for most contaminants requires expensive equipment and time-consuming procedures for the isolation, identification, and quantification of the specific contaminant. In addition, test proce-

dures, equipment, and necessary reagents differ depending on the specific toxin in question. Generally, this testing is not done routinely, but rather as an audit or if a load of milk is suspect.

Temperature

Temperature is critical, and most plants will not accept a shipment of raw milk, if it exceeds a specific temperature. As temperatures increase, microbial growth increases. Microbial growth decreases the quality of the milk, as discussed above. Most plants rely on calibrated thermometers or temperature-sensing devices to verify raw milk temperature. If raw milk temperature is above a critical level, usually 45°F as defined in the Pasteurized Milk Ordinance, it will be rejected. Generally, a lower limit is not set for milk temperature. However, a frozen load of raw milk would be difficult to unload and probably be unsuitable for processing.

Conclusions

All processors of raw milk are concerned about the quality of the incoming product. They will use a variety of tests to assess the quality of the microbial activity; fat, protein, and total solids contents; presence of antibiotics; and temperature to decide whether to accept the load of milk. Processors continue to monitor the quality of the processed milk and relate it to the raw milk quality. It is not unusual for a processor to have set standards for the incoming ingredients as a means to ensure the acceptability, quality, and safety of the final product.

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MASTITIS MANAGEMENT - EFFECTIVE METHODS TO REDUCE SOMATIC CELL COUNTS

M. J. Brouk and J. F. Smith

Summary

Mastitis is the most costly health concern in the dairy industry today. Annual losses have been estimated at \$180 to 185 per cow. Based on this figure, annual losses for Kansas producers may exceed \$15 million. Nationally, mastitis may cost the industry \$1.8 billion annually. Although treatment and premature culling for clinical mastitis are costly, about two-thirds of the cost is associated with reduced milk production caused by subclinical mastitis. Effective mastitis control programs are necessary for the dairy industry today. Prevention of subclinical mastitis is the key to lowering the somatic cell counts (SCC). Elevated bulk tank SCC (>250,000/ml) are an indication that a significant number of the cattle are infected with mastitis-causing bacteria and corrective action is required. Key areas to evaluate are cow housing, milking equipment, and milking procedures. Utilization of milk culture data is necessary to determine if elevated SCC are due to environmental or contagious organisms. In addition, cultures of milk samples from individual cows may be needed to identify cattle infected with contagious organisms. Correction of deficiencies in housing, milking procedures, and milking equipment will effectively control environmental mastitis. Identification, segregation, and future culling of animals infected with contagious organisms are necessary for control of contagious mastitis. An effective monitoring system that includes individual-cow SCC, individual-cow bacterial cultures, and bulk-tank bacterial cultures will ensure a low bulk-tank SCC and a low level of mastitis. It is a health issue that requires constant

attention, because success is achieved with attention to detail on the dairy as a whole, and lack of attention in only one segment of the dairy may result in significant increases in mastitis. Success of the program requires that all employees and the management team (managers, herdsmen, veterinarians, nutritionists, milking equipment technicians, and consultants) emphasize increasing milk quality by controlling mastitis.

(Key Words: Mastitis, Milk Quality, Bacteria, Milk Production.)

Introduction

Mastitis is the number one health concern of the dairy industry today. It is not only costly to producers at the farm level, but also reduces the value of milk for the processor and may impact the consumers' acceptability of dairy products. At the farm level, mastitis results in lower milk production, reduced milk quality, increased drug cost, increased culling, increased death losses, and increased labor expense. Although producers will focus on treatment of clinical mastitis, it is most important to develop a mastitis control program that will reduce not only the number of clinical cases, but also the number of subclinical cases. The key to effective mastitis control is prevention and a monitoring system that identifies problems early and corrects them before a significant portion of the herd is infected. Effective mastitis control involves defining the problem, developing solutions, implementing of corrective measures, and utilizing a monitoring system to identify future problems.

Defining the Problem

The first step in defining the problem is to admit that a mastitis problem exists in the herd. Many producers feel that they are producing quality milk. However, when the somatic cell counts (SCC) of bulk-tank milk are reviewed, counts that range from 400 to 500 thousand/ml are not unusual. Is this quality milk? That depends upon your definition. The legal limit is 750 thousand/ml, so the milk is under the legal limit. However, some processors discount milk with this level of SCC. Other countries already have reduced the lower limits to 500 thousand/ml, and the U.S. may need to adopt lower standards to open export markets in various countries. Yes, the milk is legal, but we can do better. Each producer should set a goal and work toward that goal. Many progressive dairy producers strive to hold bulk-tank SCC under 250 thousand/ml. A few have lower goals.

Significant production increases are associated with lower SCC. Table 1 outlines the expected losses in milk as SCC increases from 50 thousand/ml. Cows in their second or greater lactation are affected more than first-lactation cows. Their lactation average SCC of 400 thousand/ml is associated with a loss of 600 lb of milk, whereas the same SCC level in older cows is associated with a 1,200-lb loss. Currently, the average SCC of Kansas herds on DHI test exceeds 400 thousand/ml. Based on this information, milk production on Kansas dairies is reduced by over 1,000 lb/cow/lactation. It is no wonder that states that lead in milk production/cow are also those that excel in milk quality as determined by SCC.

Producers should recognize that the most costly mastitis losses are due to subclinical mastitis. Many times, producers are more interested in the latest treatment for clinical mastitis, but subclinical cases are generally more costly. Subclinical mastitis occurs when no visible changes are detected in the udder, and the milk is free of visible abnormalities. In such cases, the SCC will be elevated and the presence of bacteria may be detected in cultures. These cows not only

increase the bulk-tank SCC, but serve as a bacterial reservoir leading to the infection of additional cows.

Producers should strive to maintain a bulk-tank SCC of <250 thousand/ml. Counts above this level indicate a mastitis problem, and steps should be taken to identify the problem and start corrective action. The first step is to identify the types of organisms that are contributing to the elevated SCC. Samples of the bulk-tank milk should be cultured to identify whole-herd problems.

Samples should be taken from the bulk tank on 5 consecutive days or from five milk pickups. They need to be taken from the top of the tank after the milk has been agitated for 15 min. Every effort must be made to prevent contamination of the sample during this process. Remember that bacteria are everywhere in the environment. Hands, sampling tools, and nonsterile vials can serve as sources of contamination. In addition, sampling from the bottom of the tank can result in contamination from the valve port. Use a clean dipper or sterile syringe to remove a sample and transfer it to a sterile milk sample vial. Filling the vial 50% full is sufficient. Seal the vial with the cap and immediately place it in a freezer. Freezing the sample immediately stops bacterial growth and provides the laboratory with a sample that accurately represents the true bacterial population of the bulk tank. Allowing the sample to set in a warm room even for a short period of time will allow bacteria to grow and increase in number. Because different bacteria grow at variable rates under similar conditions, allowing growth to occur in the sample results in erroneous results. Once all five samples are collected and frozen, ship the samples to the laboratory in an insulated container with frozen ice packs. It is important to ship the samples so that they arrive at the laboratory frozen or cold. Thus, shipping method and day of shipment should be discussed with the laboratory to ensure that the samples arrive in good condition and on a day of the week that allows the laboratory to receive the samples and begin the cultures.

The laboratory should return the results of the bulk-tank cultures in a few days. The results may be returned directly to the farm or the herd veterinarian. Table 2 is useful in developing the solution to the farm mastitis problems.

Developing the Solution to Mastitis Problems

Based on the bulk-tank cultures, several decisions can be made. First, is the problem environmental, contagious, or a combination? As indicated in Table 2, environmental problems are best corrected with proper cow management. Milking clean, dry udders and utilizing correctly adjusted equipment with proper milking procedures will reduce many of the environmental pathogens and, thus, reduce environmental mastitis. The other major concern with environmental mastitis is the housing area. Cows need a clean, dry resting area. Bacteria require nutrients, warmth, and a moist environment. Removal of any of the three reduces their growth. Correction of housing deficiencies and the utilization of dry cow treatments at dry-off provides the best protection. Remember that the cow is most likely to develop a new mastitis infection in the first and last 2 wk of the dry period. Thus, the housing environment during the dry period is critical to effective mastitis-control programs.

If contagious organisms are found in the bulk-tank cultures, a different approach is needed. Because contagious mastitis is spread at milking, it is important that the infected cows be identified and segregated to prevent the spread of the organisms to additional cows. The only way to identify the infected cattle positively is through individual-cow milk cultures. This requires that a sample be taken from the cow utilizing sterile sampling techniques and submitted for bacterial evaluation. As with the bulk-tank samples, it is very important that the sample not be contaminated during the process. Bacteria are everywhere. They cling to udder hair, udder skin, milkers hands, and every surface in the milking parlor. It is recommended that gloves be worn and that the udder be clean and dry before sampling.

Samples should be taken prior to milking, and each teat end should be scrubbed with alcohol. Discard one squirt of milk prior to sampling and collect equal amounts from each teat if all quarters are being sampled. Filling the vial only 50% full is sufficient. Immediately freeze or place the vial on ice. Remember that bacterial grow well in warm, moist environments containing nutrients. Thus, warm milk is an excellent medium for bacterial growth. If the samples sit in the warm milking parlor for several hours until milking is complete, erroneous results will occur, and contagious animals may be missed. It is generally unusual for a single quarter to be infected with more than one organism. If results for individual cow milk cultures show two or more organisms, contamination likely has occurred.

Individual-cow milk samples are utilized to identify the cows infected with contagious mastitis. Once these cows are identified, they should be either culled or segregated into a separate group and milked last. The contagious pathogens are generally resistant to antibiotics. Thus, when a cow is infected, it likely will become a carrier. Separation from clean cows will minimize the risk to others. Dry treatments also are usually not effective on these organism, and if the cow remains on the farm for another lactation, it should be considered infected with a contagious pathogen. Permanent visual identification may be helpful.

Implementation of the Corrective Measures and Monitoring Systems

When problems have been identified and a control plan developed, it needs to be implemented immediately. This requires team effort, and everyone must place priority on the plan to ensure that it is implemented exactly. A monitoring system utilizing DHIA, bulk-tank SCC, bulk-tank cultures, and individual-cow milk samples at freshening should ensure that problems are detected early and corrected. When purchasing cattle, milk samples from all lactating cows should be cultured before they enter the herd. Samples from dry animals should be cultured upon freshening.

Allowing one contagious carrier to enter the herd could result in the culling of a high percentage of the herd. Effective mastitis-control programs are not based on just correcting problems but on preventing

problems from occurring. This requires constant attention to detail on the dairy as well as evaluation of culture data on a continual basis.

Table 1. Estimated Differences in Lactation Milk Yield Associated with Increased SCC Score

Lactation Average		Difference in Milk Yield ¹	
Linear SCC Score	SCC (1000s/ml)	Lactation 1	Lactation ≥2
		(lb/305 days)	
0	12.5	---	---
1	25	---	---
2	50	---	---
3	100	-200	-400
4	200	-400	-800
5	400	-600	-1,200
6	800	-800	-1,600
7	1,600	-1,000	-2,000

¹Losses are relative to yields of cows with an SCC score of 2.
Source: National Mastitis Council.

Table 2. Interpreting Results of Bulk Tank Milk Cultures

Bacteria Type	Source	Suggested Control Procedures
<i>Streptococcus agalactiae</i>	Infected udders (contagious)	Use separate towels to wash and dry udders Use postmilking teat dip Dry treat all cows at dry-off
<i>Staphylococcus aureus</i>	Infected udders (contagious)	Use separate towels to wash and dry udders Use postmilking teat dip Dry treat all cows at dry-off Cull chronically infected cows Milk infected cows last
<i>Mycoplasma</i> species	Infected udders (contagious)	Follow proper milking procedures Use premilking teat disinfection Use postmilking teat dip Milk infected cows last Culture all replacement animals Culture all cows and heifers at calving Cull infected cattle when possible Maintain a closed herd
Non- <i>agalactiae</i> <i>Streptococci</i>	Environment	Milk only clean, dry udders Improve cleanliness of housing environment Use premilking teat disinfection Use postmilking teat dip Dry treat all cows at dry-off
Coliforms	Environment	Milk only clean, dry udders Improve cleanliness of housing environment Use premilking teat disinfection Consider vaccination program
Coagulase-negative <i>Staphylococci</i>	Environment	Keep udders clean Milk only clean, dry udders Improve cleanliness of housing environment Use postmilking teat dip Dry treat all cows at dry-off

Source: National Mastitis Council.

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SILAGE MANAGEMENT: IMPORTANT PRACTICES OFTEN OVERLOOKED

*K. K. Bolsen, B. E. Brent, M. K. Siefers,
M. E. Uriarte, T. E. Schmidt, and R. V. Pope*

Summary

Four important silage management practices that are in the control of livestock producers and that are sometimes poorly implemented or overlooked entirely include: inoculating, packing, sealing, and managing the feedout face.

(Key Words: Silage, Silage Storage.)

Inoculating Silage Crops

Effective bacterial inoculants promote a faster and more efficient fermentation of the ensiled crop, which increases both the quantity and quality of the silage. Inoculants have inherent advantages over other additives, including low cost, safety in handling, a low application rate per ton of chopped forage, and no residues or environmental problems. The bacteria in commercial products include one or more of the following species: *Lactobacillus plantarum* or other *Lactobacillus* species, various *Pediococcus* species, and *Enterococcus faecium*. These strains of lactic acid bacteria (LAB) have been isolated from silage crops or silages and were selected because: 1) they are homofermentative (i.e., ferment sugars predominantly to lactic acid), and 2) they grow rapidly under a wide range of temperature and moisture conditions. Recently, several products also have contained *Lactobacillus buchneri* (a heterofermentative LAB) or strains of *Propionibacterium* (which are capable of producing propionic acid during the ensiling process).

Inoculant research at Kansas State University. Evaluation of silage additives began in 1975 in the Department of Animal

Sciences and Industry. A summary of results from over 200 laboratory-scale studies, which involved nearly 1,000 silages and 25,000 silos, indicated that bacterial inoculants were beneficial in over 90% of the comparisons. Inoculated silages have faster and more efficient fermentations — pH is lower, particularly during the first 2 to 4 days of the ensiling process for hay crop forages, and lactic acid content and the lactic to acetic acid ratio are higher than in untreated silages. Inoculated silages also have lower ethanol and ammonia-nitrogen values compared to untreated silages.

Economics of bacterial inoculants.

What is the “bottom line” calculation of the value of inoculating corn silage and alfalfa haylage for a dairy herd with an average milk production of 87 lbs per cow per day and a daily dry matter (DM) intake of 54.2 lbs? The increase in net income, calculated on a per ton of crop ensiled or per cow per day or per cow per year basis, is realized from increases in both preservation and feed utilization. The additional “cow days” per ton of crop ensiled, because of the increased DM recovery, and the increased milk per cow per day from the inoculated silage or haylage (0.25 lbs) result in a \$6 to \$7 increase in net return per ton of corn ensiled and about a \$14 to \$15 increase in net return per ton of alfalfa ensiled.

Recommendations. Why leave the critical fermentation phase to chance by assuming that the epiphytic microorganisms (those occurring naturally on the forage) are going to be effective in preserving the silage crop? Even if a dairy or beef cattle producer's silage has been acceptable in the past -- because silage-making conditions in

most regions of North America are generally good -- there are always opportunities for improvement.

Although whole-plant corn and sorghum ensile easily, research data clearly show that the quality of the fermentation and subsequent preservation and utilization efficiencies are improved with bacterial inoculants. Alfalfa (and other legumes) are usually difficult to ensile because of a low sugar content and high buffering capacity. However, adding an inoculant helps ensure that as much of the available substrate as possible is converted to lactic acid, which removes some of the risk of having a poorly preserved, low-quality silage. Finally, if producers already are doing a good job but using a bacterial inoculant for the first time, they probably will not see a dramatic difference in their silage. But the benefit will be there — additional silage DM recovery and significantly more beef or milk production per ton of crop ensiled.

Selecting a bacterial inoculant. The inoculant should provide at least 100,000 and preferably 200,000 colony-forming units of viable LAB per gram of forage. These LAB should dominate the fermentation; produce lactic acid as the sole end product; be able to grow over a wide range of pH, temperature, and moisture conditions; and ferment a wide range of plant sugars. Purchase an inoculant from a reputable company that can provide quality control assurances along with independent research supporting the product's effectiveness.

Achieving a Higher Silage Density

Achieving a high density of the ensiled forage in a silo is an important goal for dairy producers. First, density and crop DM content determine the porosity of the silage, which affects the rate at which air can enter the silage mass at the feedout face. Second, the higher the density, the greater the capacity of the silo. Thus, higher densities typically reduce the annual storage cost per ton of crop by both increasing the amount of crop entering the silo and reducing crop losses during storage. Recommendations

usually have been to spread the chopped forage in thin layers and pack continuously with heavy, single-wheeled tractors. But the factors that affect silage density in a bunker, trench, or drive-over pile silo are not completely understood. Kurt Ruppel (Pioneer Hi-Bred) measured the DM losses in alfalfa silage in bunker silos and developed an equation to relate these losses to the density of the ensiled forage (Table 1). He found that tractor weight and packing time per ton were important factors; however, the variability in density suggested other important factors that were not considered.

In a recent study, Brian Holmes, extension specialist at the University of Wisconsin-Madison, and Rich Muck, agricultural engineer at the U.S. Dairy Forage Research Center in Madison, measured silage densities over a wide range of bunker silos in Wisconsin, and the densities were correlated with crop/forage characteristics and harvesting and filling practices. Samples were collected from 168 bunker silos, and a questionnaire was completed about how each bunker was filled. Four core samples were taken from each bunker feedout face, and core depth, height of the core hole above the floor, and height of silage above the core hole were recorded. Density and particle size also were measured.

The ranges of DM contents, densities, and average particle size observed in the hay crop and corn silages are shown in Table 2. As expected, the range in DM content was narrower for the corn silages compared to the hay crop silages. The average DM content of the corn silages was in the recommended range of 30-35%. But several of the haylages were too wet (less than 30% DM), which can lead to effluent loss and a clostridial fermentation, or too dry (more than 45% DM), which can lead to extensive heat damage, mold, and the risk of a fire. The average DM densities for the hay crop and corn silages were similar and slightly higher than a commonly recommended minimum DM density of 14.0 lb/cu ft. Some producers were achieving very high DM densities, whereas others were severely underpacking. One very practical issue was packing time relative to

the chopped forage delivery rate to the bunker. Packing time per ton was highest (1 to 4 min/ton on a fresh basis) under low delivery rates (less than 30 tons/hr on a fresh basis). Packing times were consistently less than 1 min/ton (on a fresh basis) at delivery rates above 60 tons/hour.

Dairy producers can control several key factors to achieve higher densities, which will minimize DM and nutrient losses during ensiling, storage, and feedout.

Forage delivery rate. Reducing the delivery rate is somewhat difficult to accomplish, because very few dairy producers or silage contractors are inclined to slow the harvest rate so that additional packing can be accomplished.

Packing tractor weight. This can be increased by adding weight to the front of the tractor or 3-point hitch and filling the tires with water.

Number of tractors. Adding a second or third packing tractor as delivery rate increases can help keep packing time in the optimum range of 1 to 3 minutes per ton of fresh forage.

Forage layer thickness. Chopped forage should be spread in thin layers (6 to 12 inches). In a properly packed bunker silo, the tires of the packing tractor should pass over the entire surface before the next forage layer is distributed.

Filling the silo to a greater depth. Greater silage depth increases density. But there are practical limits to the final forage depth in a bunker, trench, or drive-over pile. Safety of employees who operate packing tractors and who unload silage at the feedout face becomes a concern. Packing in bunkers that are filled beyond their capacity and the chance of an “avalanche” of silage from the feedout face pose serious risks.

Table 1. Dry Matter Loss as Influenced by Silage Density

Density (lb of DM/ft ³)	DM Loss at 180 Days (% of the DM ensiled)
10	20.2
14	16.8
16	15.1
18	13.4
22	10.0

Table 2. Summary of Core Sample Analysis from the Bunker Silos

Silage Characteristic	Hay Crop Silage (87)		Corn Silage (81 silos)	
	Avg	Range	Avg	Range
Dry matter, %	42	24-67	34	25-46
Density on a fresh basis, lb/cu ft	37	13-61	43	23-60
Density on a DM basis, lb/cu ft	14.8	6.6-27.1	14.5	7.8-23.6

Protecting Silage from Air and Water

Until recently, most large bunker, trench, or drive-over pile silos in Kansas were left unsealed. Why? Because producers viewed covering silos with plastic and tires to be awkward, cumbersome, and labor-intensive. Many believed the silage saved was not worth the time and effort required. But if silos are left unprotected, DM losses in the top 1 to 3 ft can exceed 60 to 70%. This is particularly disturbing when one considers that in the typical "horizontal" silo, 15 to 25% of the silage might be within the top 3 feet. When the silo is opened, the spoilage is apparent only in the top 6 to 12 inches of silage, obscuring the fact that this area of spoiled silage represents substantially more silage than originally stored.

The most common sealing method is to place polyethylene sheet (6 mil) over the ensiled forage and weight it down with discarded tires (approximately 20 to 25 tires per 100 sq ft of surface area). Producers who do not seal need to take a second look at the economics of this highly troublesome "technology", before they reject it as unnecessary

and uneconomical. The loss from a 40 × 100 foot silo filled with corn silage can exceed \$2,000. Loss from a 100 × 250 foot silo can exceed \$10,000.

Managing the Feedout Face

The silage feedout "face" should be maintained as a smooth surface that is perpendicular to the floor and sides in bunker, trench, and drive-over pile silos. This will minimize the square feet of surface that are exposed to air. The rate of feedout through the silage mass must be sufficient to prevent the exposed silage from heating and spoiling. An average removal rate of 6 to 12 inches from the "face" per day is a common recommendation. However, during periods of warm, humid weather, a removal rate of 18 inches or more might be required to prevent aerobic spoilage, particularly for corn, sorghum, and whole-plant wheat silages.

For more information about these and other silage management practices visit the Kansas State University Silage Team's website at:

http://www.oznet.ksu.edu/pr_silage.

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MANURE AND LAGOON NUTRIENTS FROM DAIRIES USING FLUSH SYSTEMS

*T. D. Strahm¹, J. P. Harner¹,
D. V. Key², and J. P. Murphy¹*

Summary

Nine primary lagoons and solids storage basins were sampled on Kansas dairies using flush systems. These samples were analyzed for nutrient content of wastewater and sand manure. The manure moisture content in the storage basins averaged 81%. The average totals of nitrogen, phosphate, and potash were 3450, 1345, and 1420 mg/L, respectively, for flushing systems. The average totals of nitrogen, phosphate, and potash in the lagoon samples were 816, 337, and 1134 mg/L, respectively, for dairies using recycled water for flushing alleys. These data and previously reported data indicate that lagoon effluent and manure removed from basins must be managed differently between dairies using flush versus scrape systems.

(Key Words: Manure, Nutrients, Dairy, Sand, Lagoons.)

Introduction

Consulting engineers and extension educators can use the MidWest Plan Service (MWPS) MWPS-18 Handbook, Natural Resource Conservation Service (NRCS) National Engineering Handbook 651, or ASAE Standard D384.1 Manure Production and Characteristics for information on the expected daily nutrient production per given animal unit. Most of these data are based on excreted manure rather than manure that actually is being applied to the land. Assumptions as to the expected losses and location, i.e., lagoon or solids storage basin,

of the nutrients must be made based on the engineer's experience.

Many dairies are using total mixed rations and sand- or manure-bedded freestalls.

However, limited information is available on the nutrient content of waste streams from these freestalls. The purpose of this study was to characterize the manure and effluent nutrients from dairies using recycled water for flushing their facilities.

Procedures

Samples were collected from manure storage basins at nine Kansas dairies. The dairies used sand bedding or composted manure in the stalls. The dairies used flush systems to clean freestall housing and holding pen areas. The sampling was completed during spring 2000.

Manure samples were retrieved using a capped PVC cylinder attached to a metal electrical conduit handle on five of the dairies. A cord was connected to open a spring-closed lid, while the cylinder was under the surface. Depending on the amount of manure in the basin, samples were taken at depths of 2 to 3 ft. The sampler was used to open the crust and then was pushed to the desired depth before the lid was pulled open to collect the sample. Four to six individual samples were taken from around the perimeter (3 to 4 ft from the edge) of each basin and then mixed in a bucket to make one composite sample. On two dairies, solid manure

¹Department of Biological and Agricultural Engineering.

²Nemaha County Extension Agent.

samples were taken from mechanical solid separators.

Some of the lagoon samples were collected with the same sampling device. Other samples were collected with a PVC sampler that was thrown 40 to 50 ft from the edge into the water. The sampler was weighted and filled as it sank below the surface. The individual samples were combined and analyzed as one composite sample. The samples were refrigerated in 1 liter plastic bottles until sent for laboratory analysis. Servi-Tech Laboratories completed total nutrient analysis on each sample. Samples also were collected at several dairies using 30 pans placed in a field prior to land application of lagoon effluent using reel irrigation systems. These samples were taken to evaluate the variability in sprayed effluent.

Results and Discussion

Data in Table 1 show the average nutrient analysis of the manure samples taken from the solids basins. Manure samples from the two dairies that used mechanical solid separators had an ash content of about 2%. Samples from the other dairies had ash contents ranging from 4 to 13%. The electrical conductivity and pH averaged 7.5 mmho/cm and 6.4, respectively. The average total nitrogen was 3,420 mg/L of which 94% was in the organic form. The phosphate and potassium averaged 1345 and 1420 mg/L, respectively.

Table 2 shows the nutrients available from the lagoons on dairies using a flush system. The average total nitrogen (TN) was 816 mg/L, about five times higher than average values for the scrape systems. Approximately 50% of the N was in the ammonia form, and the remainder as organic N. Phosphate averaged 337 mg/L, which is 4.5 times more than the average for the scrape systems, and potash was more than double at 1134 mg/L.

The data in Table 3 for TN indicate that different management strategies are needed when pumping effluent from lagoons located on dairies using scrape and flush systems. The nutrient values for dairies using a scrap-

ing system were reported in 1999 Dairy Days. If effluent is pumped annually onto fields adjacent to a lagoon and TN rates are limited to 114 kg (250 lb) per acre, then only 2 inches of water from the lagoon storing the recycled flush water could be applied per acre. About 7 inches of water could be applied to land receiving lagoon effluent from a dairy using a scrape system. With these application rates, excessive phosphates should not be applied to cropland.

Table 4 shows nutrient concentrations and properties of samples taken from flush systems with composted manure or sand bedding. Nutrient concentrations were greater in the solid and liquid samples from facilities using composted manure, especially phosphorus. The liquid samples from composted manure bedding had greater concentrations of total dissolved solids, 5830 mg/L as compared to 3940 mg/L from sand bedding. Similarly, the solid manure samples from sand-bedded facilities contained less organic matter and more ash.

The following are initial conclusions derived from this field study:

1. The ratio of total nitrogen to phosphorus was approximately 3 in manure from dairy cows fed total mixed rations using a corn silage-based ration.
2. The moisture content of manure was 81% for dairies using flush systems with concrete basins, earthen basins, or mechanical separators.
3. Nutrient content in lagoons from dairies using recycled flush water was much higher than that found in lagoons on dairies that are scraping.
4. A comparison of flush systems showed greater nutrient concentrations when composted manure was used as bedding than when sand was used.
5. Additional data are needed from more dairies using recycled flush water to quantify the nutrients available from lagoons and storage basins.

Acknowledgment

The authors thank the dairy producers who cooperated with this study and allowed them access to their dairies.

Table 1. Nutrient Analysis of Manure Samples Taken from Storage Basins on Dairies Using a Recycled Flush System

Nutrient	Units	Average	S.D.
Organic nitrogen	mg/L	3251	768
Urea	mg/L	182	193
Nitrate - nitrogen	mg/L	17.1	28.3
Total nitrogen	mg/L	3450	805
Phosphorus (P ₂ O ₅)	mg/L	1345	643
Potassium (K ₂ O)	mg/L	1420	680
Other Properties:			
Moisture	%	80.7	4.2
Solids	%	19.3	4.2
Organic matter	%	12.6	4.9
Ash	%	6.7	4.1
Carbon/nitrogen ratio		23.0	10.9
Electrical conductivity	mmho/cm	7.5	4.5
pH		6.4	0.8
Total salts	mg/l	11786	5969

Table 2. Nutrient Analysis of Manure Samples Taken from Primary Lagoons on Dairies Using a Recycled Flush System

Nutrient	Units	Average	S.D.
Organic nitrogen	mg/L	418	150
Ammonia	mg/L	398	176
Nitrate-nitrogen*	mg/L	1.1	0.2
Total Kjeldahl nitrogen	mg/L	816	266
Phosphorus (P ₂ O ₅)	mg/L	337	173
Potassium (K ₂ O)	mg/L	1134	367
Other Properties:			
Chloride	mg/L	377	245
Total dissolved solids	mg/L	4753	1299
Water pH		7.7	0.2
Electrical conductivity	mmho/cm	7.9	1.6
Sodium adsorp. ratio	(SAR)	3.0	1.3

*1.0 mg/l = 1 or less.

Table 3. Comparison of Average Nutrient Values for Samples Taken from Storage Basins and Lagoons on Dairies Using Scrape and Flush Systems for Handling Manure

Concrete Basins			
Nutrient	Units	Handling System	
		Scrape	Flush
Organic nitrogen	mg/L	3489	3251
Urea	mg/L	1700	182
Nitrate-nitrogen	mg/L	3.2	17.1
Total nitrogen	mg/L	5191	3450
Phosphorus (P ₂ O ₅)	mg/L	2539	1345
Potassium (K ₂ O)	mg/L	4157	1420

Lagoons			
Nutrient	Units	Handling System	
		Scrape	Flush
Organic nitrogen	mg/L	80	418
Ammonia	mg/L	77	398
Nitrate-nitrogen	mg/L	0.3	1.0
Total Kjeldahl nitrogen	mg/L	156	816
Phosphorus (P ₂ O ₅)	mg/L	74	337
Potassium (K ₂ O)	mg/L	512	1134

Table 4. Comparison of Average Sample Characteristics with Composted Manure and Sand Bedding in Flush Systems

Nutrient	Units	Solid		Liquid	
		Sand	Manure	Sand	Manure
Total nitrogen	mg/L	3100	3920	760	900
Phosphorus (P ₂ O ₅)	mg/L	1300	1410	300	380
Potassium (K ₂ O)	mg/L	1260	1630	930	1410

Other Properties:

Total dissolved solids	mg/L			3940	5830
Moisture content	%	81.4	79.8		
Organic matter	%	11.3	14.3		
Ash	%	9.0	6.0		

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FLUSHING SAND-LADEN MANURE

J. P. Harner¹, T. D. Strahm¹, and J. P. Murphy¹

Summary

Sand can be handled successfully either in a scrape or flush system by developing handling systems that allow for the sand-laden manure to settle prior to the effluent entering a lagoon. The abrasiveness and density of sand create problems in handling the manure. Manure weighs about 60 lb/cu ft, whereas sand has a density of 120 lb/cu ft. Sand-laden manure will have an approximate density of 80 lb/cu ft, if 30% of the manure is sand. Because sand is heavier, it will not remain in suspension as long as manure and settles rapidly. Many problems associated with handling sand-laden manure can be avoided if the solids are stored separately from the effluent.

(Key Words: Flush, Sand, Manure, Bedding.)

Review of Flushing Sand-Laden Manure

Flushing dairy manure is an alternative to blade scraping of freestalls or holding pens. Advantages include labor reduction with automated systems, limited scraping requirements, lower operating cost, drier floors, potential reduction in odor, and cleaner facilities. An optional method of handling manure may be necessary in colder weather. Flushing does not eliminate the need to apply the manure and effluent to land at environmentally acceptable levels.

Daily water requirements for flushing vary depending on the width, length, and slope of the alley and bedding material. With

organic bedding at a slope of 3%, a minimum flush volume is 100 gal/ft of gutter width for flushing lengths of less than 150 ft. Longer lengths require more water with a suggested maximum release of 175 gal/ft of gutter width. A study of six dairies found flush water requirements ranging from 240 to 620 gal/cow/day. Another procedure suggests selecting the larger of two volumes — either 52 gal/cow/flush or 1.35 gal/sq ft of alley/ flush. Observations with sand-laden manure (SLM) suggest that a high-velocity flush system can clean alleys with less than 1 gal/sq ft, whereas low-velocity system may require more than 4 gal/sq ft.

The cleanliness of an alley depends on the energy of flush water to remove the SLM. Design practices suggest that the flushing wave needs to be 150 ft in length, 3 inches deep, and moving at a velocity of 5 ft/sec. Buildings longer than 450 ft require the flush wave to be at least 1/3 of the total length. If the length is less than 150 ft, then the design procedure is based on a 10 sec contact time. The amount of time flush water moves past a given selection of the alley is known as contact time. However, based on observed procedures, contact times of 10 min or longer often are used in flushing alleys, if the velocity is less than 3 ft/sec. These dairies are using longer flush times in an attempt to avoid scraping alleys.

The two basic flush mechanisms are high- and low-velocity systems. For purposes of this paper, a high-velocity flush system uses wave velocities greater than 5 ft/sec with 7.5 ft/sec being preferred. Low-velocity flush

¹Department of Biological and Agricultural Engineering.

systems have wave velocities of less than 5 ft/sec, generally around 3 ft/sec.

Storage structures often are used for high-velocity flush systems, and pumps generally are used for low-velocity flush systems. A tank or tower at the upper end of the area being flushed is used to store the flush water. Flushing tanks with 4 to 12 ft depth have large discharge openings. Towers have depths of 20 ft or more and discharge through 12- to 24-in-diameter pipe. A low horsepower pump is used to transfer water from the lagoon to the storage tank. Flushing-pump systems utilize the lagoon for storing the flush water. A large horsepower pump then pumps the water to the upper end when flushing is desired. Storage towers may be used with low-velocity flush systems, but piping losses reduce the flow velocity.

The release rate varies from a minimum of 10 sec to more than 60 sec for longer buildings with high-velocity flush systems. Release rates can vary from 1,000 gal/min to over 15,000 gal/min, if the system is designed properly. Flush water pumping or low velocity flush systems often are limited by the pump capacity, and the water-release rate is 60 sec or longer. Most of the pumping systems are limited to a release rate of less than 3,000 gal/min.

A simple high-velocity flush system consists of tanks that are 9 to 10 ft in diameter and 25 ft or taller. The flushing system may use a 6- to 7-ft section of 16-inch pipe exiting the tank at a right angle. This pipe has a 45° slope inlet inside the tank. Another 6- to 7-ft section of 12-inch pipe, which includes a 12-inch manual gate valve, then is used to carry the water to the flush alleys. The pipe outlet directs the water along the freestall curb. One field study found that flush velocity decreased from 11.5 ft/sec to 6.7 ft/sec as the head decreased from over 30 ft to less than 10 ft. Based on the number of freestalls and flushing three times per day, the water usage was 48 gal/stall/flush or 140 gal/day/stall. The water usage based on a 8,500 gal/min discharge rate and a 30-sec flush was equal to 0.84 gal/sq ft, giving a

flow rate of 700 gal/min and a water usage of 350 gal/ft width of gutter.

Field flush velocities were obtained from four barns using concrete tanks with manual guillotine or scissor-gate flush system. Two of the barns released the flush at a 90° angle to the alleys. The release was parallel to the long axis of the alleys in the other barns. The tanks were commonly 4 ft deep with length and width dimensions of 12 ft by 16 ft. The flush water exited the tank through an orifice measuring 8 inches by 96 inches at full opening. The flush velocities in the guillotine tanks were 6 to 9 ft/sec. The tanks with the flush water exiting at a right angle to the alley had a flush velocity 2 ft/sec slower than the other tanks.

Some scraping or manual cleaning along the freestall curb may be needed, because much of the manure is deposited here. A 0.75- to 1-inch crown in the alley is needed to direct more flush water along the curbs, if freestalls are along both sides. The crown will interfere with scraping. Recently, alleys have been sloped 0.5 to 1 inch from the outside to the freestall curb to increase the depth of the flush wave along the curb with head-to-head freestalls.

Flush water commonly is released using "pop-up" or recessed valves controlled manually or automatically. Automated valves are operated pneumatically. Discharge rate from a valve is influenced by the hydraulic characteristics of the pipeline to the valve. Common design procedures connect multiple tanks to a valve from both sides to maintain a higher head pressure and, thus, increase the discharge rate. Other release methods include a hinged plate, open pipe, and gated pipe.

Flush water is collected at the lower end of a building in a gutter alley or basin. The water flows towards a mechanical separator or gravity-settling basin. The separation allows the solids to accumulate in a basin and the liquid to drain to a lagoon.

Dairies using sand-bedded freestalls need to have a sand trap or sand separator located

ahead of the mechanical solids separator. The abrasive action of sand in the pumps and on screens in mechanical solid separators decrease equipment life and increases maintenance cost.

The mechanical separator may be an inclined screen, press roller, or screw press. The inclined screen allows the liquid to pass through the screen, and the solids remaining on the surface are transferred to a storage area. In the press roller, the flushed material passes through a pair of rollers and the water drains away. The screw press uses more pressure to separate liquids and solids. Gravity type systems use a settling basin to settle out the solids and drain off the liquids.

Based on visual inspection of alleys with sand bedded freestalls, the minimum flush velocity should be 5 ft/sec with 7.5 ft/sec being preferred. Current guidelines on release rates with 400-ft alleys seem to be adequate. The water depth at the freestall curb should be a minimum of 3 inches with 4 inches preferred. The energy of the flush water needs to be directed along the freestall curb rather than in the center of the alley.

Gravity and mechanical separations are two basic methods for settling out the sand from the manure stream prior to solids separation. Gravity basins depend on the ability of the system to slow the flush velocity to 1 to 2 ft/sec. At these velocities, the organic matter appears to remain suspended with the liquid and will discharge from the sand trap with minimal settling. Field data show that less than 3% of the solid material in the sand trap is organic material. The sand can be recovered from a solids-separating basin, because much of it settles out near the discharge pipe when a flush system is used. Generally the sand is stacked and dried prior to its reuse.

A mechanical separator has been developed that has the ability to recycle 90% or more of the sand from the waste stream. The sand is much cleaner than that from a gravity separator, because it is washed. The mechanical separator works better with coarse sand than fine sand. Studies have shown that

inclined screens are not effective in separating sand from the waste stream. The screen openings are larger than the sand particles. Sand also had a tendency to settle out upstream of the inclined separator as the flush wave velocity is reduced.

Here are some general guidelines to remember when working with sand:

1. Sand-laden manure will not stack or pile like manure mixed with organic material. It tends to spread and move away, particularly in wet weather.
2. The longer sand-laden manure is in storage, the easier it is to handle. A minimum storage of 45 days is recommended.
3. It is easier to handle sand-laden manure contained in a structure other than the lagoon or holding pond.
4. Begin the waste-handling system design by taking advantage of gravity. Use pumps and augers as a last resort in moving the manure stream.
5. Generally, the top surface will be a slurry, and initial emptying of a solids-storage basin takes time. Once the slurry is removed (for small dairies, this represents about 10%), the rest of the material in the structure will be at less than 80% moisture.
6. Flushing systems work better when the energy created by the water depth or head pressure in the flush water tower (and pumps) is used to move manure and sand rather than flush water through the pipes and elbows. A certain amount of energy is lost for every foot of pipe the flush water must move through. When flushing sand, it is better to purchase more storage towers and move them closer to the alleys than to buy pipes and elbows. If the piping system is desired, then use a larger pipe for the manifold system and do not reduce down to the pop-up valve size until after the last elbow or tee joint.

7. Some producers are experimenting with stockpiling gravity-separated sand. Most are partially blending the dirty sand with clean sand. The stockpiling period ranges from 1 to 6 mo prior to reuse. The runoff from the sand pile should be contained and transferred to the lagoon. In a recycled flush water system, the additional drainage area may be beneficial in providing some extra flush water.

Summary

Flushing can be a viable alternative to scraping of dairy manure. Facilities can be

constructed for the addition of flushing systems at a later date, even if scraping is planned in the immediate future. This requires placing the buildings at a recommended 2% slope. A 6 to 8 ft difference in elevation between the lower end of the flushed areas and the lagoon freeboard will be necessary for inclusion of separation equipment and transfer collection gutters. Inclusion of flushing systems in existing buildings must be determined on an individual basis. An adequate supply of fresh water for flushing the milk parlor and holding pen also must be available.

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SALMONELLA DUBLIN: A THREAT TO DAIRY HEIFER SURVIVAL AND FUTURE PERFORMANCE

*D. G. Schmidt, D. P. Gnad,
J. M. Sargeant¹, and J. E. Shirley*

Summary

Salmonella dublin is a bacterium that can have devastating effects in dairy herds. It is most deadly with calves that range in age from 10 days to 5 months. *Salmonella dublin* is shed from carrier animals through feces, milk, and colostrum and spread by oral ingestion. Clinical signs are not detected easily until after the infection is well established. Calves may suffer from septicemia, diarrhea, fatigue, and unthriftiness. Death is not an uncommon outcome of this disease. Clinical signs of infection in adults may range from none to enteritis or abortion. Combating the disease requires an awareness of the disease, a preventive herd health program, and attention to detail in caring for the newborn calf.

(Key Words: *Salmonella dublin*, Heifers, Calves.)

Introduction

Salmonella is an invasive pathogen that must be taken seriously in today's dairy industry. *Salmonella dublin* and *S. typhimurium* are the strains most frequently isolated from cattle. *Salmonella dublin* is the topic of concern in this report. In calves, the bacterium cause septicemia with high rates of morbidity and mortality. Clinical signs are less severe in adult cows.

Many producers purchase outside replacement heifers or utilize outside growers, placing them at risk of exposing their herd to *S. dublin*-infected animals. Calves that are

exposed to carriers of *S. dublin* are at a high risk of developing clinical salmonellosis and/or becoming carriers themselves. The most common route of transfer to uninfected animals is *S. dublin* shed by carrier animals in feces, colostrum, or milk. Only one carrier of *S. dublin* is needed to infect an entire herd. Good biosecurity practices are essential to prevent the entry and control the spread of *S. dublin* in dairy herds. This article reviews recent research concerning the effects of *S. dublin* on the survival rate and subsequent performance of dairy heifers.

Review of Research

An important step in raising replacement heifers is to ensure that newborn calves receive adequate amounts of quality colostrum shortly after birth. It is critical that this colostrum be from cows that are not carriers of *S. dublin*, because the bacteria may be ingested by the neonatal calf. Research indicates that during the time just before parturition, shedding of *S. dublin* from the cow increases; thus increasing the likelihood of it passing into the colostrum and into the calf.

Young calves are more susceptible to *S. dublin* than older calves and adults. This is partially due to higher pH (5.2) in their abomasum. The abomasal pH levels of 4.8 or less commonly found in older calves and adults are detrimental to viability of *S. dublin*. Ruminal contents from calves that are >6 wk of age also have been shown to inhibit *S. dublin*.

¹Food Animal Health and Management Center.

Calves infected with *S. dublin* do not show specific clinical signs of infection until the disease is well established. Pneumonia, septicemia, diarrhea, unthriftiness, and death commonly are seen with *S. dublin* infection. As the infection progresses, strands of intestinal mucosa and blood may be found in the feces. The loss of intestinal mucosa reduces the calf's ability to absorb nutrients and combat other infections that challenge the intestinal lining. Cattle that recover from an acute infection of *S. dublin* may shed the pathogen for 4 to 6 wk afterwards. A small number of animals may recover clinically, but remain carriers of the bacteria. Many calves that are infected with the pathogen and recover never reach their full performance potential.

Fecal culture commonly is used to diagnose *S. dublin* infections in cattle, but false negatives are common because of intermittent fecal shedding. Submitting multiple fecal samples from a single animal can minimize false negatives. However, because of cost of fecal culture and the intermittent fecal shedding by the cow, this test is not practical for herd monitoring.

Studies also show that *S. dublin* can survive up to 30 mo in dried feces, 120 days in pasture soil, 115 days in pond water, and 87 days in tap water. Therefore, good manure management must be practiced on the entire farm. Good manure hygiene practices are critical in maternity and calf rearing areas. Maternity pens should be cleaned routinely, and calves should be removed from calving areas as soon as possible and placed in clean areas free from adult manure. Calves should be fed an adequate amount of quality colostrum obtained from a *S. dublin*-free dam. Pooling colostrum from multiple cows increases the chances for calves to be exposed to *S. dublin*. Minimizing calf-to-calf contact from the minute the calf is born until weaning also is important in preventing the spread of disease.

Along with good management practices, vaccination against *S. dublin* can be used to protect neonatal calves from infection. However, vaccination alone, without good biosecurity measures, is not sufficient to prevent and control *S. dublin* infection. Preventing and controlling *S. dublin* in dairy herds can be accomplished only with a multi-dimensional approach.

Dairy Day 2000

TOTAL BLOOD PROTEIN AS AN INDICATOR OF COLOSTRAL SUFFICIENCY AND MORBIDITY IN DAIRY CALVES

*D. G. Schmidt, D. P. Gnad,
J. M. Sargeant¹, and J. E. Shirley*

Summary

Total blood protein measured in calves between 1 and 7 days of age is a good indicator of the sufficiency of colostrum intake and level of immunity passed to the calf. This measurement can be used to improve calf management strategies and thereby calf performance. Total blood protein concentrations are associated with immunoglobulin absorption in the neonatal calf, which can impact calf morbidity and mortality. Blood protein >5.5 g/dl indicates sufficient immunoglobulin absorption, and blood protein <5.0 g/dl indicates insufficient absorption. Insufficient immunoglobulin absorption increases the risk of calf morbidity and mortality. The dry cow health program, proper collection, and management of colostrum help ensure that quality colostrum is available for the newborn calf. Proper colostrum administration and low-stress calf management also ensure maximal immunoglobulin absorption. Timing of colostrum intake affects total blood protein concentrations. The calf's ability to absorb immunoglobulins is reduced significantly 12 hr after birth. Therefore, it is critical to administer colostrum during the first few hours of life. Total blood protein can be used to determine if the calf has absorbed sufficient immunoglobulins from the colostrum.

(Key Words: Blood Protein, Colostrum, Calves, Morbidity.)

Introduction

Dairy producers have to deal with many factors related to rearing baby calves. Colostrum management is one of them. Many producers attempt to increase the efficiency of their farm enterprise. When time traditionally spent in calf management is re-allocated to other areas of the farm, calf health and performance may be impacted negatively. However, colostrum management, including quality and timing of the first feeding of colostrum, is vital. It is well documented that administering an acceptable quality and quantity of colostrum within the first few hours of a calf's life greatly increases its level of immunity. Calves with sufficient colostrum intake are less likely to experience morbidity than calves with insufficient intake.

Colostrum management on some dairies includes commingling of first-, second-, and third-day colostrum into one tank. Because first-day colostrum has the highest concentrations of immunoglobulins, the pooling practice results in a diluted mixture that may be inadequate to meet the calf's immunoglobulin requirements. Colostrum <50 mg/ml (measured by a colostrometer) should not be given to calves during the first 12 hr of life, because the amount of immunoglobulin is likely to be inadequate. By measuring total blood protein from individual calves, producers can determine accurately the amount of immunoglobulin absorption ($r = 0.88$) passed

¹Food Animal Health and Management Center.

from colostrum to the calf, thus, evaluating the level of passive immunity. Our objective was to review recent research concerning the use of total blood protein as an indicator of colostrum sufficiency and morbidity in dairy calves.

Review of Research

One method of testing the level of immunity passed to the calf is to measure serum total protein (TP). This is done by collecting blood from a jugular vein of a calf between 1 and 7 days of age. The blood is centrifuged, and the serum is analyzed for TP using a refractometer calibrated for this purpose. Refractometry provides rapid and inexpensive results and is useful for monitoring passive immunity status.

Study results have shown that the relationship between the level of serum TP and morbidity and mortality of the calf is non-linear. One study reported that calves with TP concentrations >6.5 g/dl had the least level of risk, whereas calves with TP <5.0 g/dl were 3 to 6 times more likely to experience health problems, death, or both. A much greater reduction in risk was observed when TP increased from 4.0 g/dl to 5.0 g/dl than when it increased from 5.5 g/dl to 6.5 g/dl. The hazard mortality ratio was a constant value from birth to 6 mo. This ratio indicates that low concentrations of TP were

associated with high mortality throughout that entire period. Data collected from another group show similar results; the lowest risk for morbidity and mortality was detected in calves with TP >5.5 g/dl. Calves with concentrations of 5.0 g/dl to 5.4 g/dl showed a very slight increase in the risk of morbidity and mortality with the highest risk resulting from TP <4.0 g/dl. Therefore, we recommend maintaining TP >5.5 g/dl in calves for decreased risk of subsequent health problems.

These results cannot predict which calves will get ill or die and which calves will not. Some calves with TP >6.0 g/dl will experience health problems or die, but not at the rate of calves with lower TP concentrations. Serum TP is a useful and practical means of assessing immunoglobulin absorption in the neonatal calf. However, one also must pay special attention to all factors associated with rearing calves. Following proper herd health programs is important to help ensure the best performance. Herd health programs should be tailored for the individual dairy and address the problems of that dairy. Solving the problems of low quality colostrum, as well as those in the timing and amount of colostrum administered, will not eliminate neonatal morbidity and mortality. However, it is an essential step in helping to ensure more adequate, healthy, replacement heifers for the future.

Dairy Day 2000

ANTIBIOTIC VERSUS NONANTIBIOTIC PRODUCTS FOR THE TREATMENT OF PAPILLOMATOUS DIGITAL DERMATITIS (HAIRY HEEL WART) IN DAIRY CATTLE

*J. M. Sargeant¹, D. P. Gnad², J. E. Shirley,
J. Isch, H. Bathina³, and J. Lising³*

Summary

A field trial was conducted to compare oxytetracycline to three nonantibiotic therapies using bandage protocols for the treatment of hairy heel warts. Affected feet were bandaged for 4 days with either of the four products. Over a 28-day period following bandage removal, heel warts on 44 cows (11 per treatment group) were evaluated based on size, degree of pain, color, and lesion appearance. No differences were detected among treatments, suggesting that nonantibiotic therapies used in bandage protocols may be as effective as oxytetracycline.

(Key Words: Hairy Heel Warts, Therapy, Nonantibiotic.)

Introduction

Papillomatous digital dermatitis (hairy heel wart) is an emerging disease of dairy cattle, which has become an important cause of lameness. A 1996 USDA survey reported that heel warts were detected in cows on 43.5% of U.S. dairies. The presence of hairy heel warts is associated with severe lameness and decreased performance because of pain. The cause of heel warts is not fully understood; however, it is believed to be contagious in nature and likely associated with a spirochete. Many methods have been used to treat hairy heel warts, including footbaths, topical sprays, parenteral antibiotics, and bandages. Oxytetracycline solution in a bandaging protocol seems to offer the best

short-term improvement. However, the potential exists for antibiotic residuals, though none have been reported in clinical trials, and for the development of antibiotic resistance. Therefore, considerable interest exists in developing nonantibiotic products that are efficacious for the treatment of this disease.

The objective of this field trial was to compare antibiotic and nonantibiotic treatment products used in a bandaging protocol for the treatment of papillomatous digital dermatitis.

Procedures

The study was conducted on a 300-head commercial dairy farm in SE Kansas, in an area that averages 37 inches of rain per year and 190 frost-free days. The herd had experienced an increased incidence of hairy heel warts over the previous month. The milking herd was housed in a shaded dry lot with sand-bedded free-stalls and concrete alleys. There were four milking strings, one for 2-year-old cows, and three for older cows based on production. The cows were walked approximately 150 ft on a grooved concrete surface twice daily for milking in a double-13 herringbone milking parlor. Foot baths had not been used for several months and were not used during the course of this study. Premilking heifers and dry cows were housed separately in small groups on dirt drylots with natural shade.

¹Food Animal Health and Management Center.

²Department of Clinical Sciences.

³WestAgro, Inc., Kansas City, Missouri.

All adult milking cows with active hairy heel wart lesions of at least 1 cm in diameter on a single day in March 2000 were enrolled in the trial. All affected cows were evaluated in a standing position for pain and then confined in left lateral recumbency on a tilt table for further lesion evaluation and for the bandaging procedure. They were fitted with leg bands for identification throughout the trial. The lesions were evaluated for size, pain, color, dermatological characteristics, and appearance based on protocols previously developed for the standardized evaluation of hairy heel warts. The evaluation criteria were as follows:

Lesion size. Lesions were measured in two dimensions to the nearest 0.25 inch. Size was recorded as the square area of the lesion.

Pain. Scoring for pain was performed prior to restraining the animals on the tilt table. Pain was evaluated by spraying water on the lesion with a hose spray attachment from a distance of 2 ft. Prior to the actual measurement, both hind feet (or both front feet if the lesion was on a front foot) were sprayed to desensitize the animal to the water application.

0 = no demonstrable pain (does not flinch or raise foot during spraying)

1 = sensitive (flinches and/or raises foot for less than 2 sec)

2 = severe (holds foot off ground for at least 2 sec)

Color.

0 = flesh, indicating a healed lesion

1 = black

2 = gray

3 = white

4 = red

Lesion appearance.

0 = healed

1 = proliferative. Raised lesions with many hair-like skin growths protruding from the surface. Hyperkeratinization of the skin and swelling are associated with mature lesions.

2 = granulomatous. Lesion containing a terry cloth-like texture associated with the intermediate stages of infection.

3 = ulcerative. Flat, red, and raw lesion often involving bleeding, pain, and erythema; usually associated with lesions in the early stages of infection.

Animals were allocated randomly to each of four treatments, using permuted blocks of four to ensure equal numbers per group. Treatments A, B, and C represented different nonantibiotic products, and treatment D was oxytetracycline. The study was conducted in a triple blind manner; neither the herd owner, the person conducting the evaluations, nor the person performing the statistical analysis was aware of the active ingredient in each treatment.

Following cleaning of the lesion with water, treatments were administered by adding 35 ml of each of four treatments to 10 grams of cotton balls. The treatment-soaked cotton was placed against the lesion and bandaged in place using one roll of Vetwrap® and an outer layer of duct tape for waterproofing. The bandages were removed after 4 days.

Follow-up evaluations were performed at the time of bandage removal (day 4) and at days 18 and 32.

The effects of treatments on the overall change in score for size, pain, color, and appearance categories were evaluated using Kruskal-Wallis one-way analysis of variance. The outcome was calculated as the difference between the score on day 1 and at 28 days following bandage removal. Separate analyses were conducted for each category. The effect of treatment on the rate of change in each category over the course of the study was evaluated using repeated measures analysis of variance for each category. Using these two statistical approaches allowed us to test for differences between overall changes in the heel wart lesions among treatments and differences in the rate of change in the heel wart lesions among treatments over time.

Results

The average days in milk of the affected cows was 216 (range: 13 to 415). The group included 25 first-lactation cows, 7 second-lactation cows, 8 third-lactation cows, and 2 fourth-lactation cows. Two animals were culled between week 2 after bandage removal and week 4 after bandage removal for reasons unrelated to the heel wart lesions.

Overall changes. Figure 1 shows the mean percentage changes in lesion size, pain score, color, and lesion appearance between the start and the end of the trial by treatment.

No statistically significant differences were detected in the average changes among treatments.

Changes over time. No significant differences occurred in the rate of change over time for any of the lesion categories (Figures 2 through 5).

The results show that nonantibiotic products can be as effective as oxytetracycline when used in bandage protocols. Further work is needed to develop and market non-antibiotic therapies.

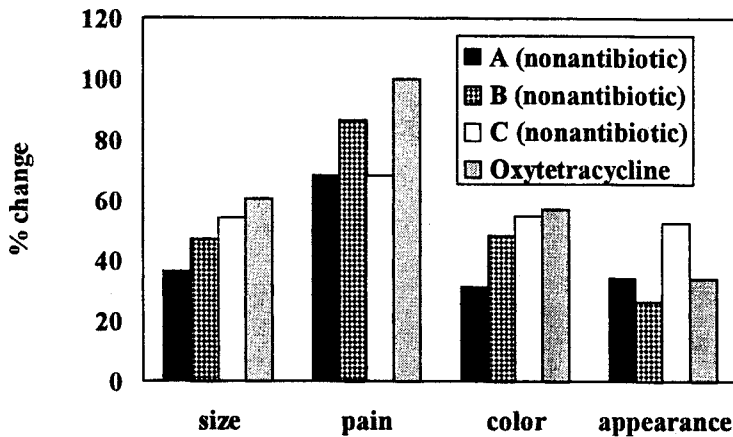


Figure 1. Average Percent Change between Day 1 and Day 32 by Treatment Group.

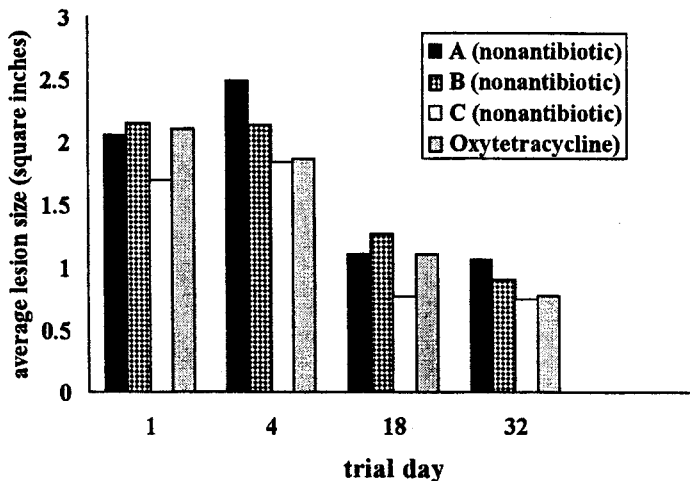


Figure 2. Average Lesion Size over Time by Treatment Group.

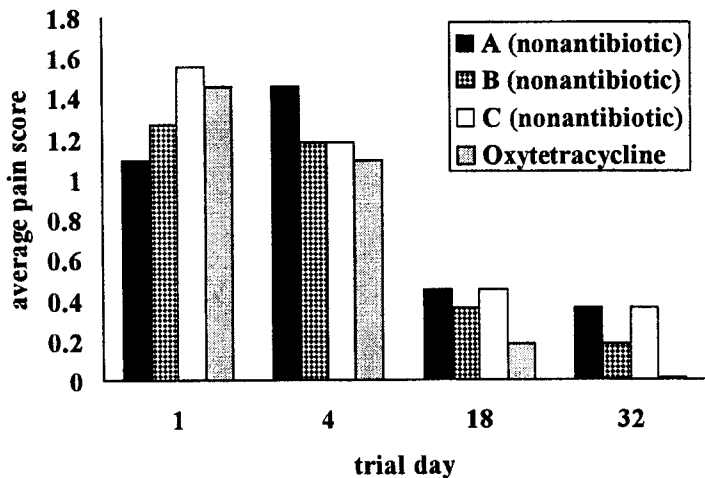


Figure 3. Average Pain Score over Time by Treatment Group.

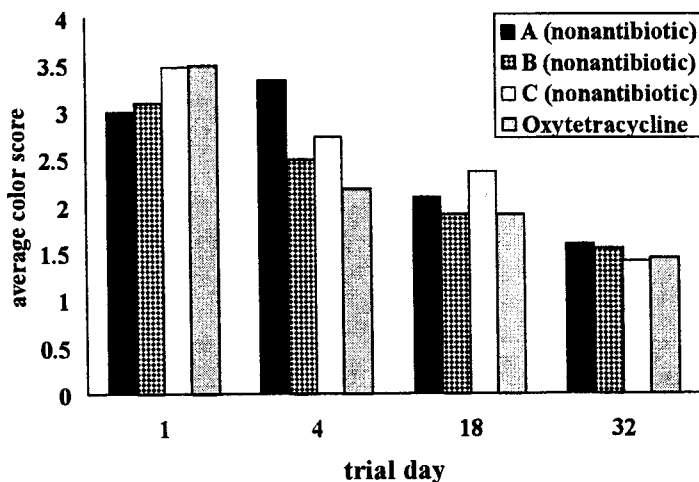


Figure 4. Average Color Score over Time by Treatment Group.

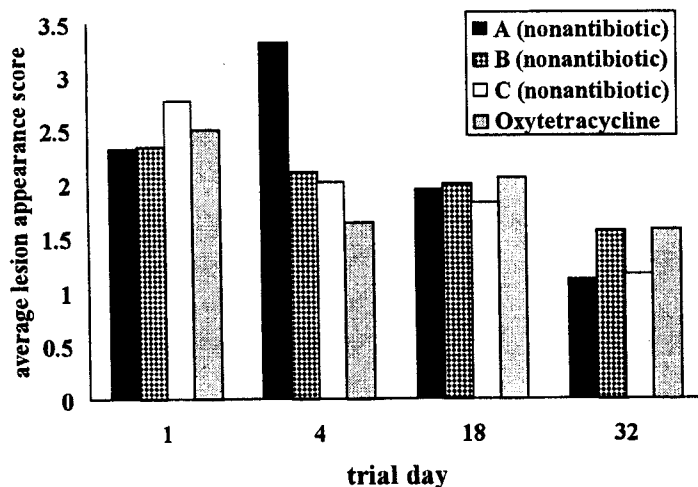


Figure 5. Average Lesion Appearance Score over Time by Treatment Group.

Dairy Day 2000

ECONOMICS OF COOLING COWS TO REDUCE SEASONAL VARIATION IN PEAK MILK PRODUCTION

K. C. Dhuyvetter¹

Summary

The economic impact of cooling cows to reduce the seasonal variation in peak milk production was estimated using research-based lactation curves and peak production numbers for a commercial dairy operation in Kansas. Reducing the seasonal drop in peak production that occurs in the late summer and fall months by 29% or more is profitable for second or higher lactation cows. This reduction represents an increase in total milk production over the entire lactation of slightly over 1% and an increase in the average annual peak production of only 1 lb. This indicates that achieving at least the breakeven level for second and higher lactation cows is a reasonable expectation. Based on the peak milk production for the farm considered in this analysis, it would not pay to cool first lactation cows, because their peak production was lower and exhibited very little seasonality. The economics of cooling cows is insensitive to feed prices, and only moderately sensitive to milk prices suggesting that the decision to cool dairy cows is basically independent of these factors. Although the benefit of cooling dairy cows, in terms of increased production, will depend on the type and effectiveness of the cooling system used, this analysis indicates that even small improvements in production can be economical.

(Key Words: Economics, Heat Stress, Cooling Cows.)

Introduction

Heat stress can have a large impact on cow comfort and milk production, thereby impacting the profitability of dairy operations. Drops in milk yield of 10-25% following heat stress are not uncommon in high-producing herds. With production decreases of this magnitude, providing supplemental cooling to avoid, or at least minimize, the impact of heat stress, most likely will be economical. However, in order for producers to make informed decisions, they need quantitative information; thus, an economic analysis that quantifies the returns associated with cooling cows (i.e., heat-stress abatement) is warranted.

Studies examining the returns to reducing heat stress often consider the heat-stress time period only. However, published lactation curves suggest that a 1-lb increase at peak production will produce an additional 225 to 250 lb of milk over the entire lactation. Therefore, any economic analysis of heat-stress abatement should account for the increased production over a cow's entire lactation. The purpose of this study was to estimate the economic returns associated with reducing, or even eliminating, seasonal variation in peak milk production for a commercial dairy herd in Kansas using a hypothetical research-based milk lactation curve to simulate milk production and the costs associated with a fan and sprinkler-based cooling system.

¹Department of Agricultural Economics.

Procedures

A partial budget was used to examine the impact of heat-stress abatement (i.e., adding cooling equipment) on net returns. A partial budget includes four values: 1) increased revenue, 2) decreased costs, 3) increased costs, and 4) decreased revenue. For the dairy analyzed here, increased revenue is simply the increased milk production from reducing heat stress. Quantifying the costs expected to decrease from reducing heat stress is difficult, and such costs likely vary considerably between operations. Costs that might decrease as a result of reduced heat stress are those associated with health and reproduction, i.e., those factors directly related to cow comfort. Because of the difficulty in measuring these costs accurately, they are not included in this analysis, and as a result the returns associated with heat-stress abatement should be viewed as lower bounds. Increased costs associated with cooling cows are the higher feed costs from increased feed intake and fixed and variable costs of the cooling system itself (depreciation and interest on fans and sprinklers, as well as electricity and water costs). It is assumed that no reductions in revenue are associated with cooling cows.

Figure 1 shows daily milk production as a percent of peak production for a hypothetical research-based lactation curve. Using this approach, total milk production over the entire lactation will be a function of peak production. Therefore, increasing peak production will increase daily milk production at each day. For example, a cow that peaks at 100 lb/day will have proportionately higher production every day of her lactation than a cow that peaks at 90 lb/day. Furthermore, because these lactation curves are proportionate, a peak that is 10% lower (e.g., 90 lb/day vs. 100 lb/day) will result in total milk production over the entire lactation that is also 10% lower.

Figure 2 shows the peak milk production by lactation and month for a commercial dairy operation in Kansas with freestall barns but not using any fans or sprinklers for cooling cows. The interpretation of the data in

Figure 2 is as follows – the average peak milk production (lb/cow/day) for all cows in their second lactation that peaked in the month of March was 100 lb. Peak production was relatively steady for 7 mo of the year (December through June), but it was less for the other 5 mo, and considerably so in August, September, and October. The reductions in peak production for cows in their second lactation were similar to those in their third or higher lactations on a percentage basis -- about a 13% to 14% difference between highest and lowest peaks. The decrease in first-lactation cows followed a similar seasonal pattern but was considerably less (4% difference between highest and lowest peaks). A logical question then is: How much would it be worth to reduce, or possibly eliminate, the reduction in peak production that occurs in July through November by cooling cows? Using partial budgets and the lactation curve shown in Figure 1, the economic return to reducing the seasonal variation in peak production as displayed in Figure 2 was estimated to answer this question.

Results and Discussion

The dashed lines in Figure 2 represent what the peak production would be if the “gap” between the heat stress months (July through November) and the average of January through June were reduced by 50%. Table 1 shows the returns to reducing the variability in peak production for first, second, and third and higher lactation cows at three “gap reduction” levels. Economic returns are based solely on changes in milk production and do not account for any reproductive or health benefits that might be associated with cooling cows. Production is shown for 1) base peak production levels, i.e., the solid lines in Figure 2; 2) a 25% reduction in the gap between heat stress months and January through June; 3) a 50% reduction in the gap, i.e., the dashed lines in Figure 2; and 4) a 100% reduction in the gap, i.e., the elimination of seasonal variation in peak production. Increased feed costs were based on an additional 0.40 lb of feed for each additional lb of milk. Costs of the cooling system were based on fixed and

variable costs of fans and sprinklers operated for 100 days per year. In addition to returns over feed costs, a benefit/cost ratio was calculated that simply looks at the dollars of revenue that are generated for every dollar of expense. Defined this way, a ratio of less than 1.0 would be unprofitable.

Given that the peak production of first lactation cows was considerably less than that of older cows and very little seasonality occurred in peak production, cooling these cows is not profitable when all costs are included (i.e., benefit/cost ratio <1.0). Completely eliminating the seasonal variation, i.e., a 100% gap reduction, increases total milk production by less than 1%. However, returns over feed costs are positive (\$13.11 per cow per year), indicating that this small increase in production is sufficient to pay for the added feed cost.

Cooling second and higher lactation cows at relatively small percentage improvements is economical. The breakeven over total costs is about a 29% reduction in the gap, which represents an increase in total milk production of slightly more than 1% and an increase in the annual average peak production of only 1 lb. If the difference (i.e., gap) in peak production between heat stress months and other months can be reduced by 50% for older cows, the payback is greater than 1.5:1. This compares to a payback of only 27¢ for every dollar spent on cooling first lactation cows at this gap-reduction

percentage. This indicates that the profitability of cooling cows will depend on the age distribution of the herd. At a 50% reduction in the gap, a dairy that has an equal distribution of first, second, and third+ lactation cows in the herd would recognize a return of nearly \$1.25 for every \$1 spent on expenses associated with cooling cows. Furthermore, if the cooling equipment were used only on higher lactation cows, the returns would be about \$1.75 for every \$1 spent. Thus, given that most dairies have second or higher lactation cows, management strategies that increase peak production by reducing the effects of heat stress most likely will be profitable.

Prices of feed and milk were varied from their initial levels to determine how sensitive returns were to these two factors. Decreasing milk prices from \$12/cwt to \$11 and \$10/cwt resulted in breakeven gap reductions for second and higher lactation cows of 32% and 36%, respectively (initial breakeven was 29%). Increasing feed costs from \$120/ton to \$150 and \$180/ton increased the breakeven percentages to 30% and 33% respectively. Thus, the decision to cool cows is relatively insensitive to both of these factors and especially so to feed prices. This suggests that for high-producing dairy herds, cooling cows over a wide range of feed and milk prices and with relatively small improvements in production most likely will be economical.

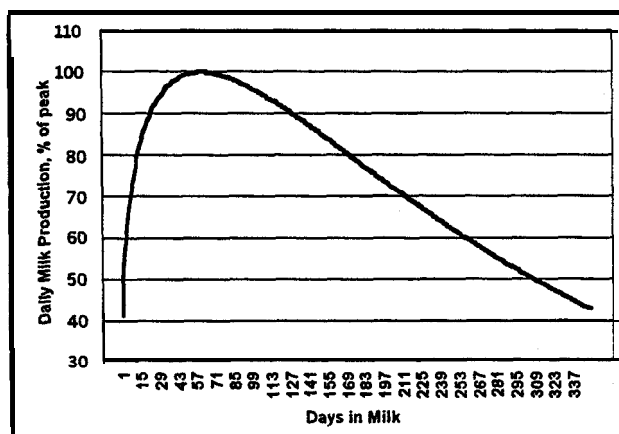


Figure 1. Hypothetical Research-Based Lactation Curve.

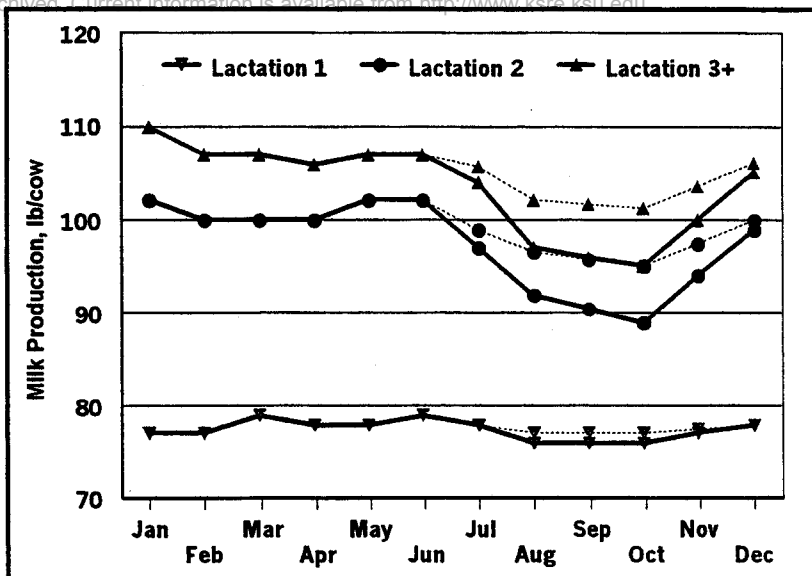


Figure 2. Peak Milk Production by Lactation for a Commercial Dairy in Kansas.

Table 1. Impact of Increasing Peak Production during Heat Stress Months¹

Lactation	Base ²			25% Reduction in Gap ³			50% Reduction in Gap ³			100% Reduction in Gap ³		
	L1	L2	L3+	L1	L2	L3+	L1	L2	L3+	L1	L2	L3+
Peak, lb/d ⁴	77.4	97.3	103.4	77.6	98.2	104.4	77.7	99.1	105.4	78.0	101.0	107.3
Total, lb ⁵	20,354	25,580	27,190	20,392	25,823	27,447	20,431	26,067	27,705	20,507	26,555	28,220
Increase in total from base, %				0.19	0.95	0.95	0.38	1.91	1.89	0.75	3.81	3.79
Per Cow Average:												
Return over feed costs, \$/cow/yr ⁶				\$3.28	\$20.83	\$22.00	\$6.55	\$41.66	\$44.00	\$13.11	\$83.33	\$88.01
Benefit/cost ratio (income/cost) ⁷				0.13	0.85	0.90	0.27	1.70	1.80	0.54	3.41	3.60
Dairy Average: ⁸												
Return over feed costs, \$/cow/yr ⁶				\$15.37			\$30.74			\$61.48		
Total return over feed costs, \$/yr ⁶				\$9,222			\$18,444			\$36,888		
Benefit/cost ratio (income/cost) ⁷				0.63			1.26			2.51		

¹Heat stress months are assumed to be July through November.

²Base represents the production without cooling cows (solid lines in Figure 1).

³Gap refers to the difference between peak production in heat stress months and the average for January through June.

⁴Average peak production during the year.

⁵Total production for 350-day lactation (production is annualized by multiplying by 12.0/13.5) – milk at \$12.00/cwt.

⁶Feed costs are based on 0.40 lb of feed for each additional lb of milk and \$120/ton diet cost.

⁷Cost of cooling system is based on annual cost of fans and sprinklers (\$14,680 per year for 100 days of cooling).

⁸Dairy average is based on 600 cows and equal numbers of all three lactations (i.e., 33.3% L1, 33.3% L2, 33.3% L3+).

Dairy Day 2000

MONENSIN: AN OVERVIEW OF ITS APPLICATION IN LACTATING DAIRY COW DIETS

J. M. DeFrain and J. E. Shirley

Summary

The efficiency of feedstuff utilization by ruminal microorganisms and the cow's genetic ability to convert feed nutrients into milk and milk components are major factors that influence the profitability of a dairy herd. Monensin's ability to modify the movement of ions across biological membranes leads to alterations in bacterial populations and subsequent changes in the proportion of volatile fatty acids produced during ruminal fermentation. Manipulating ruminal microbial populations with ionophores has the potential to improve performance by reducing ketosis, acidosis, and bloat and increasing digestive efficiency. Monensin improves fiber digestion by preventing suboptimal ruminal pH, enhances amino acid use by reducing the degradation of dietary protein, and improves the energy status of periparturient animals. Monensin is not approved for use in diets for lactating dairy cows at this time, but its status is currently under review by the U.S. Food and Drug Administration. If approved, monensin will provide another management tool to the dairy industry.

(Key Words: Ionophore, Health, Efficiency.)

Introduction

The profitability of a dairy herd is a function of the milk price at the farm level and the cost of production (overhead and operational). The herd manager can influence the cost of production but has little influence on the price received for milk. An analysis of individual items contributing to the total cost of production reveals that feed cost constitutes approximately 50% (range of

35-60%). Thus, the efficient use of feedstuffs is a high priority issue for dairy producers and researchers.

Feed efficiency is defined herein as pounds of energy-corrected milk produced per pound of feed consumed. Energy-corrected milk is used, because it accounts for volume and energy content of milk (fat, protein, and lactose). Feed consumed is less than feed offered, but feed wasted during handling and feeding is a separate management issue. Milk and milk component yield by the dairy cow is a function of her genetic makeup and environment. The diet fed to the cow is a major aspect of the environmental factors that influence her performance. If we assume that the cow is fed a properly formulated diet and other environmental factors are favorable, then her response to the diet depends on the efficiency of feedstuff utilization by ruminal microorganisms and the cow's genetic ability to convert feed nutrients into milk.

The purpose of this review is to explore the implications of including monensin in diets for lactating dairy cows, because it is under review by the U.S. Food and Drug Administration (FDA) as a potential feed additive.

Monensin's Mode of Action

Monensin and other ionophores have been used as growth promotants in livestock production systems for decades. However, monensin is known most notably for its ability to alter the ruminal microbial population, leading to increased proportions of the gluconeogenic precursor propionate. An ionophore's mode of action is to modify the

movement of ions across biological membranes. Two major classes of bacteria exist in the rumen: gram negative and gram positive. Gram positive bacteria (cells possessing a complex outer membrane) are resistant to ionophores, whereas gram negative bacteria are susceptible. Bacterial cell membranes consist of a lipid bilayer that regulates nutrient exchange across the membrane. Ionophores bind to gram-negative bacteria and disrupt nutrient exchange that interferes with proper cell function and can result in cell death. Alterations in bacterial populations lead to changes in the proportions of volatile fatty acids (VFAs) produced during ruminal fermentation.

Effects on Animal Health Status

Management tools such as DHI records, rBST, and a solid preventive herd health program play a vital role in achieving higher production efficiencies. Monensin is yet another management tool that could enhance production efficiency and improve animal health status. As the dairy cow progresses through various production phases (i.e., dry period, early, mid-, and late-lactations) she experiences a wide array of physiological and dietary changes. These changes require intense nutritional management to prevent herd health problems and maximize performance. Manipulating the ruminal microbial population with ionophores could improve performance by reducing ketosis, acidosis, and bloat and increasing digestive efficiency.

The transition from a nonlactating to a lactating state increases nutrient demand at a time when intake is less than optimal. The cow responds by mobilizing tissue to support lactation, which increases the risk of metabolic disorders such as ketosis and fatty liver. Monensin has the potential to reduce the incidence of ketosis, because it increases the proportion of propionate, a gluconeogenic precursor, whereas total ruminal VFA concentrations either increase or remain unchanged. Increasing ruminal production of propionate (contributes to glucose production) reduces the need to synthesize glucose

from the amino acid pool in order to maintain adequate concentrations of blood glucose.

Feeding diets containing an adequate supply of nonstructural carbohydrates to meet the lactational demand of the high-producing dairy cow often predisposes the animal to borderline acidosis. The initial onset of ruminal acidosis stems from an overproduction of VFAs that lowers ruminal pH (<5.5). This affects the ruminal microbial population, allowing lactic acid producers to outnumber lactic acid utilizers. Monensin decreases the *Streptococcus bovis* population, a major lactate producer, and enhances the lactic acid utilizers. The net effect of monensin on ruminal acidosis yields a more desirable ruminal pH (<5.8) for improved fiber digestion.

Monensin also has demonstrated the ability to reduce bloat. Two major products resulting from ruminal fermentation are acids and gases. The inability to eructate free gas from the rumen results in bloat. This inability is caused by an accumulation of fluids, solids, foam, and(or) slime that prevents the free gas from reaching the cardia to be expelled via eructation. Monensin reduces the production of methane, and carbon dioxide, the rate of rumen fill, and growth of microbial species responsible for slime production. A reduction in these bloat-provocative substances reduces the incidence of bloat within the herd.

Monensin also has a protein-sparing effect and reduces ruminal ammonia production. Its depressive effect on overall ruminal cell numbers reduces activities of proteolytic and deaminative enzymes, thus, increasing the quantity of dietary protein escaping ruminal degradation. This dietary protein then would be available for postruminal absorption. Other researchers have found that monensin reduces protozoan numbers *in vivo*. Because protozoa play a role in bacterial protein recycling, ruminal ammonia concentration is lower for cattle receiving monensin.

Feeding Recommendations

Monensin has not been cleared for use in lactating dairy cow diets in the U.S. However, data have been submitted to the U.S. Food and Drug Administration for review. Monensin has been cleared for use in other countries, and the feeding recommendations contained herein are based on their findings.

The impact of monensin on the digestion of other dietary ingredients should be considered. Incorporating monensin into a high-fiber diet generally will result in increased milk production because of increased energy (in the form of glucose) available for milk synthesis. However, when monensin is formulated into an energy-dense diet, dry matter intake is reduced and milk production unchanged, resulting in increased production efficiency. Monensin also improves protein nutrition of the dairy cow, because more amino acids are absorbed postruminally and made available for milk protein synthesis or gluconeogenesis rather than being degraded by ruminal microbes. This protein-sparing effect is primarily due to a reduction in protein deamination activity in the rumen, making more effective use of amino N. Therefore, diets designed for monensin inclusion should contain sufficient high quality protein to ensure the availability of essential amino acids.

Because monensin enhances the energy status of the cow, the greatest response to feeding monensin is observed during the first 3 to 4 wk after calving and continues until peak milk production. During the immediate prepartum period, the cow is in a negative energy balance as fetal growth is maximized and the mammary gland is preparing for the

subsequent lactation. This energy imbalance continues during early lactation. Therefore, the positive effect of monensin on performance will continue until peak lactation (usually 50 to 60 days postpartum). Shortly after this time, feed intake is sufficient to meet the demand for milk synthesis. Generally, no response in milk production has been observed after peak milk production but increases in body weight and body condition resulted from the increased energy available to the cow.

The amount of monensin to include in the diet will be determined during the FDA review process. Doses used in research trials have ranged from 10 ppm (equivalent to 10 mg/kg of feed dry matter) to 450 mg per head per day. Research indicates that an interaction may occur between dose and other factors such as diet and stage of lactation. In general, feeding monensin at different amounts has decreased milk fat percentage but had an insignificant effect on milk protein content. Feeding monensin under conditions known to decrease milk fat (low fiber, high grain diets, and heat stress) has shown the greatest negative impact on milk fat.

In conclusion, a recent review indicated that monensin increased milk yield by approximately 2 lb per day. Most importantly, monensin could be useful in the prevention of periparturient diseases, which are oftentimes invisible costs impacting the efficiency of production. If it is approved for use in the U.S., diet formulation strategies will vary between farms based on production goals. In the end, monensin's impact on the efficiency of milk production should help improve the dairy farm balance sheet.

Dairy Day 2000

EFFECT OF LEVEL OF SURFACE-SPOILED SILAGE ON THE NUTRITIVE VALUE OF CORN SILAGE-BASED RATIONS

*L. A. Whitlock, M. K. Siefers, R. V. Pope,
B. E. Brent, and K. K. Bolsen*

Summary

Twelve ruminally cannulated crossbred steers were used to determine the effect of level of surface spoilage in corn silage-based rations on dry matter (DM) intake and nutrient digestibilities. Irrigated corn was harvested at the 80% milkline stage of maturity and ensiled in pilot-scale bunker silos, which were 3 ft in depth, and a 9-ft-diameter AgBag[®]. After 90 days, the bunkers were sealed with a single sheet of polyethylene, and this silage was designated "spoiled". The silage in the AgBag was designated "normal". The four rations contained 90% silage and 10% supplement (DM basis), and the proportions of silage in the rations were: A) 100% normal; B) 75% normal: 25% spoiled; C) 50% normal: 50% spoiled; and D) 25% normal: 75% spoiled. Dry matter intake decreased in a linear manner as the proportion of spoiled silage increased from 0 to 75%. Steers consuming the normal silage ration had higher DM, organic matter, crude protein, neutral detergent fiber, and acid detergent fiber digestibilities than those fed the three rations that contained spoiled silage. The addition of surface-spoiled silage also had negative associative effects on nutrient digestibilities, and the integrity of the forage mat in the rumen was destroyed partially by even the lowest level of spoiled silage.

(Key Words: Corn Silage, Surface Spoilage, Nutritive Value.)

Introduction

A silage management practice sometimes overlooked by dairy producers is the discarding of spoiled silage. Because sealing bunker, trench, and drive-over pile silos

with a polyethylene sheet is not 100% effective, aerobic spoilage occurs to some degree in virtually all sealed silos. The objective of this study was to determine the effect of including three levels of "surface-spoiled silage" on the nutritive value of whole-plant corn silage-based rations.

Procedures

Twelve crossbred steers, fitted with ruminal cannulas, were used in the study. A single source of irrigated corn (Pioneer 3394) was harvested at the 80% milkline stage of maturity and chopped to a 10 mm particle length. Three pilot-scale bunker silos, which were approximately 3 ft in depth, and a 30-ft section of a 9-ft diameter AgBag[®] were filled with alternating loads of chopped forage. After 90 days, the bunkers were sealed with single sheets of 0.6 mil polyethylene, and these silages were designated "spoiled". The silage in the AgBag[®] was designated as "normal". The four experimental rations contained 90% silage and 10% supplement (on a DM basis), and the proportions of silage in the rations were: A) 100% normal, B) 75% normal:25% spoiled; C) 50% normal:50% spoiled, and D) 25% normal:75% spoiled. The rations were fed once daily at 0700, and the amount fed was adjusted so that approximately 10% of the as-fed ration was in the feed bunk at the end of each 24-hr period.

Results and Discussion

The pH and chemical composition of the whole-plant corn silages fed are shown in Table 1. The composition of the spoiled silage is reported for each of the two distinct visual layers, designated as the original top 18 inches and bottom 18 inches, and for a

composite of the two layers after they were mixed, which represents the spoiled silage as it was actually fed in rations with 25%, 50%, or 75% spoilage. With ash content as the internal marker, the estimated proportions of the original top 18-inch and bottom 18-inch spoilage layers in the spoiled composite silage were 23.8 and 76.2%, respectively. The normal corn silage had higher DM and OM contents and slightly lower starch and CP contents than the spoiled composite silage. The normal corn silage also had low NDF and ADF percentages, which reflect the high proportion of grain in the ensiled crop. The high ash and fiber contents of the spoiled composite silage are associated with poor preservation efficiency and very high OM losses during the aerobic, fermentation, and storage phases.

The original top 18-inch layer was visually quite typical of an unsealed layer of silage that has undergone several months of exposure to air and rainfall. It had a foul odor, was black in color, and had a slimy, “mud-like” texture, and its extensive deterioration during the 90-day storage also was reflected in very high pH, ash, and fiber values. The “slime” layer comprised 5.4, 10.7, and 16.0 % of the DM in rations with

25%, 50%, or 75% spoilage, respectively. The original bottom 18-inch layer had an aroma and appearance usually associated with wet, high-acid, corn silage — a bright yellow to orange color, a low pH, and a very strong acetic acid smell.

The original depth of the packed, whole-plant corn in the bunker silos was about 36 inches; however, the final depth of the spoiled silage was only about 22 inches, with about 7 and 15 inches in the top and bottom depths, respectively (Figure 1). This settling of the ensiled crop that occurred during the 90 days the bunker silos remained unsealed — approximately 14 inches — is typical of settling depths observed in unsealed bunker, trench, or drive-over pile silages.

The addition of surface-spoiled silage had large negative associative effects on feed intake and DM, OM, NDF, and ADF digestibilities (Table 2), and the first increment of spoilage had the greatest negative impact. Examination of ruminal contents showed that the spoiled silage also had partially or totally destroyed the integrity of the “forage mat” in the rumen. The results clearly showed that surface spoilage reduced the nutritive value of corn silage-based rations more than was expected.



Figure 1. Surface-Spoiled Silage with a Slimy Layer of 7 Inches (Top) and an Acidic Layer of 15 Inches (Bottom).

Table 1. pH and Chemical Composition of the Whole-Plant Corn Silages Fed in the Metabolism Trial

Silage	pH	DM	OM	Starch	CP	NDF	ADF
		%	----- % of the DM -----				
Normal	3.90	38.0	94.7	22.3	6.9	42.6	23.4
Spoiled top layer, composite of the original top 36 inches	4.79	26.4	90.9	24.3	9.9	48.9	31.0
<u>Spoilage layers</u>							
Original top 0-18 inches (slime layer)	8.22	19.1	80.0	2.7	17.7	57.6	48.3
Original top 18-36 inches (acidic layer)	3.67	27.6	94.3	26.1	6.7	48.5	25.5

DM = dry matter, OM = organic matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber.

Table 2. Effect of the Level of Spoiled Silage on Nutrient Digestibilities for Steers Fed the Four Whole-Plant Corn Silage Rations

Item	% Spoiled silage (% Slimy layer)	Ration			
		0 (0)	25 (5.4)	50 (10.7)	75 (16.0)
DM intake, lb/day		17.5 ^a	16.2 ^b	15.3 ^{b,c}	14.7 ^c
DM intake, % of body weight		2.36 ^a	2.22 ^b	2.10 ^{b,c}	2.04 ^c
		----- Digestibility, % -----			
Dry matter		74.4 ^a	68.9 ^b	67.2 ^b	66.0 ^b
Organic matter		75.6 ^a	70.6 ^b	69.0 ^b	67.8 ^b
Crude protein		74.6 ^a	70.5 ^b	68.0 ^{b,c}	62.8 ^c
Neutral detergent fiber		63.2 ^x	56.0 ^y	52.5 ^y	52.3 ^y
Acid detergent fiber		56.1 ^a	46.2 ^b	41.3 ^c	40.5 ^c

^{a,b,c}Means within a row with no common superscript differ (P<.05).

^{x,y}Means within a row with no common superscript differ (P<.10).

Dairy Day 2000

INTAKE AND PERFORMANCE OF DAIRY COWS FED WET CORN GLUTEN FEED DURING THE PERIPARTURIENT PERIOD

*A. F. Park, J. M. Defrain, M. J. Meyer,
J. E. Shirley, E. C. Titgemeyer, T. T. Marston,
J. F. Gleghorn, and L. E. Wankel*

Summary

Eight primiparous and nine multiparous Holstein cows were used in a randomized block design to determine the effect of wet corn gluten feed in the diet during the last 21 days of gestation on dry matter intake and early postpartum performance. Multilactation cows fed wet corn gluten feed maintained a higher dry matter intake and intake as a percentage of body weight during the last week before calving than cows fed the control diet. First-lactation cows fed wet corn gluten feed consumed less dry matter, both total and as a percentage of body weight, across calving than first-lactation cows fed the control diet. Milk, milk components, and blood metabolites were not influenced by diet. Wet corn gluten feed may help alleviate the depression in intake typically observed during late gestation for multiparous but not primiparous cows.

(Key Words: Wet Corn Gluten Feed, Transition Cow, Intake.)

Introduction

The 30% decrease in dry matter (DM) intake often observed in dairy cows during the last week before calving is of interest, because it appears to be associated with an increase in body fat mobilization, the onset of fatty liver, and a lower DM intake after calving. The exact cause of this depression in intake and its physiological role remain unclear. Efforts to reduce the severity of this intake depression or reduce its effects on nutrient balance have not been very successful.

Wet corn gluten feed (WCGF) increased DM intake and milk yield in two lactating-cow studies at Kansas State University. The observed improvement in intake may have been due partially to an increase in dietary fiber digestibility and a positive effect on ruminal pH as reported by others. If this is the case, then its inclusion in close-up diets might reduce the severity of the observed prepartum intake depression and enhance DM intake immediately after calving. Our objective was to evaluate the effect of wet corn gluten feed on DM intake and performance of dairy cows during the periparturient period.

Procedures

Eight primiparous and nine multiparous Holstein cows were used in this study. Cows were randomly assigned to a 20% WCGF diet (DM basis) or control diet (Table 1). Cows were housed in a tie-stall barn, and experimental diets fed from 21 days prior to projected calving date until calving. All cows received a common diet after calving. Cow performance was measured through 4 wk postpartum. Daily feed intakes, milk weights, and body weights were recorded for individual cows. Body condition scores were assigned weekly (1 = thin and 5 = fat). Milk samples (AM, PM, and composite) were obtained on day 6 of lactation, and the contents of protein, fat, lactose, solids-not-fat, milk urea nitrogen (MUN), and somatic cells were determined by the Heart of America DHI Laboratory, Manhattan, KS. Blood samples were collected from the tail vein on days 21, 3, and 1 prior to projected calving, and on days 1, 2, 6 and 10 postpartum.

Results and Discussion

The experimental diets and their chemical composition are shown in Tables 1 and 2, respectively. Expeller soybean meal (Soybest) replaced solvent soybean meal in the WCGF diet to balance ruminally degradable protein, and WCGF replaced a portion of the alfalfa hay and corn grain. The WCGF diet contained more moisture than the control diet and was higher in neutral detergent fiber but similar to the control diet in acid detergent fiber. The diets were similar in NE_L , because the control diet contained less fat and more nonfiber carbohydrates.

The average DM intakes during the pre- and postpartum periods were numerically, but not significantly, higher for primiparous cows fed the control diet (Table 3). First-lactation cows fed WCGF tended ($P=0.15$) to be heavier than those fed the control diet, but body condition was similar between treatments. Multilactation cows were similar in body weight and average DM intake during the pre- and postpartum periods, but those fed WCGF tended to lose more body condition during the first 30 days after calving. The difference in apparent DM intake responses between first- and multilactation cows fed WCGF may have resulted from the difference in nonfiber carbohydrate content of the two diets. The working hypothesis that fiber digestibility of the WCGF would be sufficient to offset the reduction in nonfiber carbohydrates that occurred when it replaced part of the corn grain in the diet seems to fit multilactation but not first-lactation cows. Irrespective of diet, DM intakes averaged 25.8 and 39.5 pounds per head daily during the prepartum period for first- and multilactation cows, respectively. Older cows also consumed more DM as a percent of body weight than first-lactation cows (2.41 vs 1.85%). Because intake in first-lactation cows is limited by body capacity, body condition, or both, they may be more responsive to diets higher in starch than multilactation cows.

Including WCGF in lactating cow diets improved DM intake in earlier studies. These results provided the basis for this

study, because of the current interest in the depression in DM intake routinely observed prior to calving. The use of WCGF in prepartum diets may offer a means of maintaining dietary fiber, while improving nutrient delivery to the cow because the fiber fraction of WCGF is hypothesized to be more digestible than alfalfa fiber. The multiparous cows responded to WCGF as expected; DM intake decreased by 8% between 1 and 2 wk prepartum compared to a 16% decrease for control cows. Conversely, first-lactation cows fed WCGF experienced a 23% drop in intake between 1 and 2 wk prepartum compared to an 11% decrease for those fed the control diet. The decrease in DM intake observed for all cows was less than the 30% often reported, because our values represent the decrease experienced between the average intake during days 7, 8, and 9 and days 1, 2, and 3 prepartum instead of 1 to 3 wk prepartum.

Milk yield and composition data are shown in Table 4 and reflect the average daily milk yield for the first 30 days postpartum and milk composition on day 6 postpartum. No differences were observed in milk yield across treatments for either the first or multi-lactation cows. Milk composition was variable among cows within treatments, and the number of cows used in the study was not sufficient to detect differences except for somatic cells. Cows consuming WCGF had a higher somatic cell count than those consuming the control diet. These results differ from the results of earlier studies and may reflect the limited number of observations.

The most interesting observation in this study was that milk yield during the first 30 days of lactation was not affected by the difference observed in prepartum intake depression. We realize that this is a small number of observations on which to make a final judgement, but the results indicate that the degree of intake depression during the week before calving may be insignificant as an indicator of postpartum performance. Further studies with larger numbers of cows are warranted.

None of the cows in the study experienced clinical ketosis, milk fever, displaced abomasum, or dystocia. Calf birth weights were not affected by WCGF in first-lactation cows (91 vs 88 lb, control vs WCGF, respectively), but multilactation cows fed the control diet produced larger calves than cows fed WCGF (104 vs 79 lb, respectively). The reason for the observed difference in birth weights is not apparent from the data collected in this study. The multilactation cows were similar in body weight, body condition, and average dry matter intake during the last

2 wk before calving. No treatment differences occurred in plasma total alpha amino nitrogen, glucose, or urea nitrogen (Table 5) during the prepartum period.

In summary, cows fed WCGF during the close-up dry period performed as well as those fed a standard diet. Further research with other diet formulations and more cows per treatment group is needed to clarify the benefits or deficiencies derived from the inclusion of WCGF in diets for close-up dry cows.

Table 1. Diet Compositions

Ingredient	Prepartum Diets		Common Postpartum Diet
	Control	WCGF ¹	
Alfalfa hay	15.0	12.5	30.0
Prairie hay	20.0	20.0	-
Corn silage	23.0	23.0	14.5
Whole cottonseed	-	-	9.6
Wet corn gluten feed	-	20.0	-
Corn grain, ground	30.2	13.4	32.4
Soybean meal, 48% CP	9.1	-	5.1
Soybest ³	-	8.5	4
Wet molasses	-	-	1.2
Vit./min. premix ²	2.7	2.6	3.2

¹Wet corn gluten feed.

²Vitamin and mineral premix = dical; limestone; Na bicarbonate; Mg oxide; trace mineralized salt; vitamins A, D, E; and selenium.

³Expeller soybean meal.

Table 2. Chemical Compositions (% DM) of Experimental Diets

Nutrient	Prepartum Diets		Common Postpartum Diet
	Control	WCGF ¹	
Dry matter, %	77.2	68.0	81.5
Crude protein, %	13.9	14.3	16.8
RUP ² , % of DM	5.55	5.95	7.73
NE _L , Mcal/lb	0.68	0.67	0.77
Fat, %	3.04	3.66	4.78
Neutral detergent fiber, %	36.4	42.6	29.1
Acid detergent fiber, %	21.5	22.7	19.4
Nonfiber carbohydrate, %	39.1	31.4	41.4
Calcium, %	0.85	1.13	1.21
Phosphorus, %	0.48	0.46	0.55
Sodium, %	0.22	0.17	0.37
Potassium, %	1.33	1.37	1.41
Chlorine, %	0.41	0.37	0.36
Sulfur, %	0.15	0.19	0.18

¹Wet corn gluten feed.

²Rumen-undegraded protein.

Table 3. Prepartum and Postpartum Measurements

Item	Prepartum			Postpartum		
	Control	WCGF ¹	SEM	Control	WCGF	SEM
First-lactation cows (n = 8)						
DMI ² , lb/day	26.7	24.9	1.3	37.3	34.8	1.5
DMI as % of BW ³	1.9	1.8	0.12	2.9	2.8	0.15
BW, lb	1385	1435	15	1283	1259	51
BCS ⁴	3.6	3.5	0.11	3.2	3.3	0.2
Rectal temperature, °F	101.4	101.1	0.2	101.1	101.4	0.2
Urine pH	8.2	8.3	0.06	8.3	8.3	0.3
Fecal pH	6.86	6.90	0.06	6.4	6.5	0.06
Multilactation cows (n = 9)						
DMI, lb/day	39	40	2.0	54.2	53.4	2.6
DMI as % of BW	2.43	2.39	0.09	3.7	3.4	0.14
BW, lb	1632	1634	29	1508	1524	31
BCS	3.0	2.9	0.2	2.8	2.6	0.09
Rectal temperature, °F	101.5	100.9	0.2	101.7	101.1	0.2
Urine pH	8.3	8.3	0.03	8.3	8.4	0.09
Fecal pH	6.6	6.7	0.08	6.3	6.4	0.09

¹Wet corn gluten feed.

²Dry matter intake.

³Body weight.

⁴Body condition score (1 = thin and 5 = fat).

Table 4. Milk Production and Composition

Item	Prepartum Diets		SEM
	Control	WCGF ¹	
First-lactation cows (n = 8)			
Milk, lb/day	63.3	64.6	3.2
Fat, %	4.19	4.50	0.21
Protein, %	3.7	3.78	0.10
Lactose, %	4.81	4.69	0.05
SNF, %	9.34	9.29	0.14
SCC, × 1000 ^a	140	191	42
MUN, mg/dL	9.90	10.51	1.14
Multilactation cows (n = 9)			
Milk, lb/day	86.7	85.8	3.2
Fat, %	3.68	3.97	0.28
Protein, %	4.14	4.07	0.16
Lactose, %	4.55	4.69	0.09
SNF, %	9.46	9.56	0.15
SCC, x 1000 ^a	190	360	11
MUN, mg/dL	11.46	11.80	0.77

¹Wet corn gluten feed.

^aDifferent ($P < 0.01$) from control diet.

Table 5. Prepartum Plasma Total Amino Acid Nitrogen (TAAN), Glucose, and Plasma Urea Nitrogen (PUN)

Item	Prepartum Diets		SEM
	Control	WCGF	
First-lactation cows			
TAAN, mM	2.30	2.38	0.05
Glucose, mg/dL	73.2	72.9	1.8
PUN, mg/dL	8.8	9.3	0.5
Multilactation cows			
TAAN, mM	2.3	2.4	0.09
Glucose, mg/dL	65.2	66.4	0.9
PUN, mg/dL	10.4	10.6	0.4

Dairy Day 2000

DETERMINATION OF THE AMOUNT OF WET CORN GLUTEN FEED TO INCLUDE IN DIETS FOR LACTATING DAIRY COWS

*M. J. VanBaale, J. E. Shirley, M. V. Scheffel,
E. C. Titgemeyer, and R. U. Lindquist*

Summary

Twenty-four multiparous Holstein cows were used in six 4×4 Latin squares with 28-day periods to determine inclusion rates for wet corn gluten feed (WCGF) in diets for lactating dairy cows. Cows were housed in a tie-stall barn and fed diets to meet or exceed NRC (1989) nutrient requirements. Experimental treatments were 1) control, 2) WCGF constituting 20%, 3) WCGF constituting 27.5%, and 4) WCGF constituting 35% of the diet dry matter. Cows fed WCGF consumed more dry matter ($P<0.01$) and produced more ($P<0.001$) milk, energy-corrected milk, and fat-corrected milk than cows fed the control diet. Dry matter intakes were 58.9 lb/day for control and 60.2 lb/day for those cows consuming WCGF diets. Cows fed the control diet produced 83.2 lb/day of milk, whereas those fed WCGF diets produced 91.5 lb/day. Production efficiency was increased ($P<0.001$) on the WCGF diets. The percentage of fat in milk, total protein production, and milk urea nitrogen were higher ($P<0.01$) for cows fed WCGF diets than controls. Plasma glucose, total alpha-amino nitrogen, urea nitrogen, and tryglycerides were similar between cows fed the control and WCGF diets. No differences occurred in percentages of protein, lactose, or solids-not-fat content, nor was somatic cell count affected by the addition of WCGF. Body weight and condition score were not affected by treatment. We conclude that WCGF is an excellent feed for lactating dairy cows when included in the diet at 20%, 27.5%, or 35% of the dry matter.

(Key Words: Wet Corn Gluten, Lactating Cows, Milk Yield.)

Introduction

Wet corn gluten feed (WCGF) is a potential feedstuff for dairy cows located near a source. Data from studies conducted with feedlot steers suggest that it improves average daily gain and dry matter intake, reduces acidosis, and yields feed efficiency values comparable to those with corn. Wet corn gluten feed is relatively low in starch (18 to 22% of dry matter, DM), and high in neutral detergent fiber (42% of DM), with a protein fraction that is very degradable (65%) in the rumen. Lactation diets formulated to complement these characteristics should optimize the use of WCGF. The objectives of our study were to evaluate the effects of WCGF on the performance of lactating dairy cows when it was substituted in the diet for a portion of the forage and corn grain and to determine the optimal amount of WCGF to include in diets for multiparous, lactating dairy cows.

Procedures

Twenty-four multiparous Holstein cows averaging 65 days in milk were used in six 4×4 Latin squares with 28-day periods. Cows were housed and fed in a tie-stall facility at the Kansas State University Dairy, Manhattan, KS, and were fed individually diets formulated to meet or exceed NRC (1989) nutrient requirements. Diets were formulated to be isocaloric and isonitrogenous with similar amounts of neutral and acid detergent fiber, rumen-undegradable protein (RUP), and DM. Alfalfa hay and corn silage were used as forages, and corn as the primary grain. Expeller soybean meal (Soybest, Grain States Soya, Delevan, KS), 48% solvent soybean meal, and blood meal

were used to balance diets for RUP. Treatments were control (no WCGF) and WCGF at inclusion amounts of 20, 27.5, and 35% of diet replacing a mix of alfalfa hay, corn silage, and corn grain.

Diets were fed free choice as a total mixed ration and issued twice daily to ensure 10%orts. Daily milk production and feed intake were recorded, and milk samples (AM-PM composite) were collected weekly and analyzed for milk composition: milk protein, fat, lactose, solids-non-fat (SNF), milk urea nitrogen (MUN), and somatic cells (Heart of America DHI Laboratory, Manhattan, KS). Cows were weighed and scored for body condition at the beginning of the study and at the end of each 28-day period. Body weights (BW) were obtained immediately after the AM milking on 2 consecutive days, and the average was used for analysis. Blood samples were collected from the coccygeal vein during the final week of each period, and the harvested plasma was frozen at -4°F until analyzed for glucose, urea nitrogen, and total alpha amino nitrogen (TAAN).

Results and Discussion

Cows fed WCGF produced more ($P<0.01$) milk and energy-corrected milk (ECM) than cows fed the control diet. Cows fed diets containing 20 and 27.5% WCGF (% of DM) consumed more ($P<0.05$) DM as

a percentage of BW than cows fed the control or 35% WCGF diet. The resulting increase in milk yield can be explained partially by the increase in DM intake, but production efficiency (lb milk/lb DM intake) also improved in cows fed WCGF. Milk fat percentage was lower ($P<0.05$) in milk from cows fed 20 and 35% WCGF compared to controls. Cows fed WCGF produced more ($P<0.01$) milk protein, SNF, and lactose than cows fed the control diet, primarily because of the increase in milk yield. Cows fed 27.5 and 35% WCGF had greater ($P<0.01$) MUN than cows fed control or 20% WCGF.

Somatic cell count, BW, and body condition score were unaffected by dietary inclusion of WCGF. Plasma glucose, TAAN, and total triglycerides were similar among diets, but plasma urea nitrogen increased ($P<0.05$) when cows consumed WCGF. Fecal pH tended to be greater ($P=0.06$) for cows fed the 27.5 and 35% WCGF diets, whereas urine pH decreased ($P<0.05$) when WCGF was included in the diet.

In summary, WCGF substituted for a mix of alfalfa hay, corn silage, and corn grain in diets of multiparous Holstein cows increased ECM yield. Cows fed 35% WCGF (% of DM) were most efficient, but intake and ECM production data indicated that 27.5% WCGF (% of DM) is the optimum inclusion level.

Table 1. Ingredients and Nutrient Compositions of Experimental Diets

Ingredient	Wet Corn Gluten Feed, % of DM			
	0	20	27.5	35
Alfalfa hay	30.0	20.0	20.3	18.4
Corn silage	24.5	9.8	9.8	7.4
Whole cottonseed	9.6	9.7	9.7	9.8
Wet corn gluten feed	-	19.2	26.5	33.6
Corn grain, ground	32.4	26.7	20.7	18.3
Soybean meal, 48% CP	5.1	2.0	0.5	-
Expellers soybean meal	4.0	8.1	7.2	7.0
Wet molasses	2.2	1.3	1.3	1.3
Blood meal	-	-	0.75	0.90
Vit./Min. premix ¹	3.2	3.2	3.3	3.3
Nutrients				
Dry matter, %	81.7	75.0	71.3	69.2
CP ² , %	16.7	17.3	17.7	17.9
RUP ³ , % of CP	36.1	37.2	36.7	36.6
NE _L ⁴ , Mcal/lb	3.75	3.84	3.75	3.84
Fat, %	4.9	5.4	5.4	5.6
NDF ⁵ , %	29.4	31.7	33.3	34.4
ADF ⁶ , %	19.6	17.8	18.3	17.8
NFC ⁷ , %	42.5	39.7	36.7	36.2

¹Vitamin and mineral premix = dical; limestone; Na bicarbonate; Mg oxide; trace mineral salt; vitamins A, D, E; and selenium.

²Crude protein.

³Rumen undegradable protein.

⁴Net energy for lactation.

⁵Neutral detergent fiber.

⁶Acid detergent fiber.

⁷Nonfiber carbohydrate.

Table 2. Lactational Performance of Cows

Item	Wet Corn Gluten Feed, % of DM				SEM
	0	20	27.5	35	
DMI ¹ , lb/day	58.9 ^{bc}	60.9 ^{ab}	61.4 ^a	58.3 ^c	0.36
DMI, % of BW	4.25 ^b	4.42 ^a	4.43 ^a	4.20 ^b	0.052
Milk, lb/day	83.2 ^b	91.5 ^a	91.5 ^a	91.5 ^a	0.49
ECM ² , lb/day	82.9 ^b	89.5 ^a	89.9 ^a	89.9 ^a	0.49
ECM/DMI	1.41 ^b	1.47 ^a	1.47 ^a	1.53 ^a	0.015
Milk fat, %	3.47 ^a	3.28 ^b	3.33 ^{ab}	3.21 ^b	0.05
Milk protein, %	3.18	3.20	3.20	3.20	0.017
Milk lactose, %	4.84	4.88	4.88	4.88	0.012
Milk SNF ³ , %	8.80	8.86	8.86	8.86	0.023
Milk fat, lb/day	2.86	2.97	3.01	2.93	0.023
Milk protein, lb/day	2.67 ^b	2.90 ^a	2.90 ^a	2.90 ^a	0.016
Milk lactose, lb/day	4.03 ^b	4.47 ^a	4.47 ^a	4.47 ^a	0.026
Milk SNF, lb/day	7.30 ^b	8.10 ^a	8.07 ^a	8.10 ^a	0.045
Milk urea N, mg/dL	15.14 ^b	15.02 ^b	15.76 ^a	16.01 ^a	0.20
SCC ⁴ , × 1000	91	217	139	175	59

¹Dry matter intake.

²Energy-corrected milk.

³Solids-not-fat.

⁴Somatic cell count.

^{a,b,c}Row means not bearing common superscripts differ ($P < 0.05$).

Table 3. Plasma Metabolites

Item	Wet Corn Gluten Feed, % of DM				SEM
	0	20	27.5	35	
Triacylglycerol, mg/dL	14.46	14.39	14.24	14.32	0.61
Urea N, mg/dL	11.61 ^b	12.45 ^a	13.05 ^a	12.96 ^a	0.25
TAAN ¹ , mM	2.48	2.48	2.58	2.57	0.057
Glucose, mg/dL	67.7	68.8	68.3	68.9	0.76

¹Total alpha-amino nitrogen.

^{a,b}Means not bearing common superscripts differ ($P < 0.05$).

Dairy Day 2000

RELATIONSHIP AMONG CONCENTRATIONS OF MILK UREA NITROGEN AND PLASMA UREA NITROGEN AND FEEDING TIME

E. E. Ferdinand, J. E. Shirley, M. J. Meyer, A. F. Park, M. J. VanBaale, and E. C. Titgemeyer

Summary

Eight Holstein cows were used to determine the relationship among milk urea nitrogen (MUN), plasma urea nitrogen (PUN), and feeding time. We first established that MUN concentrations were similar in concentration among quarters by comparing milk samples from each quarter just before milking. In order to determine if collecting a sample of milk from a quarter influenced the MUN in samples taken later, samples were obtained from the right front quarter (RF) at 2, 4, 6, and 8 hr after the AM milking and from the left front quarter (LF), right rear (RR), and left rear (LR) at 4, 6, and 8 h after the AM milking, respectively. The MUN in samples obtained from RF at 4 hr was lower ($P < 0.01$) than corresponding samples taken from LF, but samples from RF at 6 and 8 hr did not differ from corresponding samples obtained from RR and LR. We concluded that by 6 hr, the effect of previous milking on MUN concentration disappeared because of dilution. To determine the influence of feeding time on MUN concentrations, cows were fed half of their normal PM feeding, injected with oxytocin at the subsequent AM milking to reduce residual milk, and offered surplus feed after the AM milking. Milk samples were collected at 2, 4, 6, 8, 10, and 12 hr after feeding from RF, LF, RR, LR, RF, and LF quarters, respectively. Blood samples were obtained from the coccygeal vein at hourly intervals after feeding with the last sample collected 12 hr after feeding. The MUN concentrations at 2, 4, 6, and 8 hr were similar. The MUN at 10 hr was similar to those at 2 and 8 hr, less than that at 4 and 6 hr, and greater than that for the 12 hr sample. Concentrations of PUN peaked at 2 hr postfeeding, then gradually declined through

12 hr postfeeding. The MUN peaked at 6 hr postfeeding and then declined. Time after feeding significantly influenced PUN and MUN concentrations.

(Key Words: MUN, PUN, Feeding Time.)

Introduction

Crude protein in dairy cow diets consists of ruminally degradable and undegradable fractions. Ruminal microbes utilize degradable protein to meet their requirements. A portion of this degradable protein appears in the lower tract as microbial protein that can be digested, absorbed, and utilized by the cow's body. Undegradable protein passes through the rumen and can be digested and absorbed in the lower tract. The optimal amount of each protein fraction to include in the diet is influenced by the amount of milk produced. Milk production dictates the amount of metabolizable protein required and influences total feed intake by the cow. Ruminally degradable protein and carbohydrates in the diet influence the efficiency by which rumen microorganisms incorporate dietary rumen degradable protein into microbial protein. Generally, the efficiency of protein utilization in the rumen decreases as protein intake increases or the microbial population decreases. One method of evaluating protein utilization in the rumen is to measure plasma urea nitrogen (PUN), a by-product of ammonia clearance from the blood. This detoxification event occurs in the liver, where amine groups are bonded to form urea for excretion primarily in the urine. Urea also is recycled back into the rumen via the salivary glands or excreted in the milk. The urea nitrogen in milk (MUN) is correlated highly with that in blood. Thus,

MUN provides a convenient method of estimating PUN.

Feed intake and dietary content of ruminally available protein and rumen soluble carbohydrates affect MUN. Changes in dietary ingredients that result in more or less ruminally available protein, carbohydrates or both usually increase or decrease MUN if feed intake remains relatively constant. Protein not used by the cow contributes to unnecessary feed costs and excretion of nitrogen into the environment. Concentrations of MUN provide a convenient method to evaluate efficiency of nitrogen utilization among diets. The objective of this study was to determine the influence of feeding time on MUN and PUN concentrations.

Procedures

Eight Holstein cows past peak daily milk production were housed and fed in tie-stall facilities at the Kansas State University Dairy Teaching and Research Center, Manhattan. Diets were formulated to meet or exceed NRC (1989) recommendations. Cows were fed a total mixed ration with alfalfa hay and corn silage as the forages and corn as the cereal grain. Whole cottonseed and mechanically extracted soybean meal were used as the primary sources of supplemental fat and protein. Diets were formulated to contain .78 Mcal NEL/lb dry matter, 17% crude protein, 40% nonfiber carbohydrate, 6.8% rumen undegradable protein, and 10.2% rumen degradable protein on a dry matter basis. Cows were moved into the tie-stall barn 3 days before the beginning of Experiments 1 and 2 and 10 days before Experiment 3. Averages for daily dry matter intake (DMI), crude protein intake (CPI), milk production, energy-corrected milk (ECM), and MUN/lb DMI for the 11-d experimental period are shown in Table 1. Milk samples were analyzed by the Heart of America DHI Laboratory, Manhattan, KS.

Experiment 1

The objective of this experiment was to determine whether quarter samples collected before complete milk-out accurately reflect

the MUN concentrations of the total milk in the mammary glands and whether MUN values vary among quarters.

At the AM milking, milk samples were obtained from each quarter before attaching the milking machine, and a composite sample was taken from the weigh jar after milking. Milk samples were analyzed for concentration of fat, protein, solids-not-fat (SNF), lactose, somatic cell count (SCC), and MUN.

Experiment 2

This experiment was conducted to determine if the process of collecting milk from a quarter influenced the MUN concentrations in samples obtained from the same quarter at 2, 4, 6, and 8 hr after milking. Sampling procedures consisted of predipping the teat, wiping the dip off, removing three to five squirts of milk, and collecting the sample. Milk samples were obtained from the right front (RF) quarter 2, 4, 6, and 8 hr after the AM milking. Milk samples were collected from the left front (LF) quarter at 4 hr after the AM milking, the right rear (RR) quarter at 6 hr after the AM milking, and the left rear (LR) quarter 8 hr after the AM milking.

Experiment 3

Experiment 3 was conducted after results of experiments 1 and 2 were known. The objective of this experiment was to determine the influence of feeding time on concentrations of MUN and PUN.

Cows were limit fed the night before the experiment to encourage intake the next morning. At the AM milking, cows were injected with 80 IU of oxytocin to remove residual milk. Cows were fed immediately following milking. Milk samples were collected at 2, 4, 8, 10, and 12 hr after feeding from the RF, LF, RR, LR, RF, and LF quarter, respectively. Samples were analyzed for fat, protein, SNF, lactose, SCC, and MUN. Blood samples were collected from the coccygeal vein beginning 1 hr after feeding and at hourly intervals thereafter, with the last sample collected 12 hr after feeding. Plasma was separated immediately and

frozen until analysis for glucose, total alpha amino nitrogen (TAAN), and PUN.

and lactose increased linearly ($P<0.01$) over time.

Results

Experiment 1

The MUN concentrations in milk samples collected immediately before complete milk-out were not different among individual quarters. Urea nitrogen in milk from quarters, except the RF, differed ($P<0.05$) from that of the composite sample (Table 2). Percentages of milk fat were similar among quarters, but were greater in the composite sample ($P<0.05$) than in the quarter samples. Milk protein percentages among individual quarters did not differ, but were greater in samples from RF and LF than in the composite sample. Percentages of solids-not-fat and lactose in milk were not different among individual quarter and composite samples. Fewer ($P<0.05$) somatic cells were detected in milk from LF than milk from LR, but counts were similar among other quarters and the composite (Table 2).

Experiment 2

The MUN concentrations in samples taken from the RF at 4 hr after complete milk-out and 2 hr after the first sample were lower ($P<0.01$) than those in samples taken from LF at 4 hr (Table 3). Samples obtained at 6 and 8 hr after milking contained similar concentrations of MUN among quarters sampled.

Experiment 3

Variation in milk composition over time after feeding is shown in Table 4. Milk urea nitrogen peaked at 6 hr postfeeding and decreased linearly ($P<0.01$) through 12 hr postfeeding (Figure 1). Concentrations of MUN in milk samples obtained at 2, 4, 6, and 8 hr after feeding were numerically, but not significantly ($P>0.05$), different. Samples at 4 and 6 h were different. The 12 h postfeeding sample contained less ($P<0.01$) MUN than other samples. Milk fat percentages decreased linearly ($P<0.01$) over time, whereas percentages of milk protein, SNF,

The PUN concentration peaked at 2 hr postfeeding (15.77 mg/dL), then declined to 10.65 mg/dL at 12 hr postfeeding (Figure 1). A linear ($P<0.01$) relationship was observed between PUN and time after feeding; however, PUN concentrations were not different between samples taken 1, 2, 3, and 4 hr after feeding. Average PUN and MUN values for the 12 hr period were similar, 13.4 mg/dL and 13.6 mg/dL, respectively. Plasma glucose (Table 5) was lowest (67.43 mg/dL) at 3 hr postfeeding, highest at 9 hr postfeeding, similar among other sampling times, and best described by a quadratic contrast ($P<0.01$). Plasma TAAN was not influenced by time after feeding (Table 5).

Discussion

The primary objective of this study was to determine the influence of feeding time on concentrations of MUN and PUN. However, sampling techniques had to be verified before this could be accomplished. First, we had to establish that MUN concentrations were similar among individual quarters and that quarter sample values accurately reflected values obtained from a milk sample obtained after complete milk-out of the entire udder (composite sample). Results from Experiment 1 demonstrated that MUN concentrations were similar among quarters and those from all quarters except one differed from the composite sample. However, the concentrations in the three quarter samples and the composite were within 0.5 mg/dL and would not affect management decisions concerning the diet.

The second factor to evaluate was whether prior sampling influenced the MUN value of a later sample. The results from Experiment 2 indicated that MUN concentrations were affected in samples obtained less than 4 hr after a quarter was first sampled. The sampling procedure in Experiment 3 allowed adequate time (6 hr) between samples from the same quarter for dilution, thereby negating effects of previous samplings from the quarter.

Because most producers obtain milk samples for MUN analysis at either the AM or PM milking, but not both, feeding time before each milking may not be the same. In addition, when cows are milked by groups, milking time following feeding may vary among groups. Results from Experiment 3 indicate that sampling time after feeding alters MUN and PUN concentrations. Concentrations of MUN peaked at 6 hr post-feeding and declined through 12 hr post-feeding. Therefore, sampling milk for MUN concentration, without regard to feeding time, can affect the results and lead to incorrect interpretations.

Conclusions

Because time of sampling postfeeding affects MUN and PUN concentrations, it must be considered when interpreting results and making feeding decisions. According to our results, milk should be sampled at 6 hr postfeeding in order to obtain the peak MUN concentration. On the farm, MUN values obtained from samples taken at the AM milk-

ing in one test period and the PM milking in the next test period will vary, if feeding time before milking varies. This is important for evaluating responses of cows to diet changes that may have occurred during the month. Furthermore, MUN concentrations should not be compared among groups when their feeding times prior to milking vary. Time after feeding also should be considered when sampling for PUN. Samples obtained at 2 hr postfeeding reflect peak ammonia clearance from the blood.

Information gained from this study will assist producers in the interpretation of MUN data collected from their herd. Diet changes designed to increase the efficiency of nitrogen utilization by the dairy cow depend on correct interpretation of data routinely available to the producer.

Acknowledgments

Appreciation is expressed to Mike Scheffel and employees at the KSU tie-stall barn and to Tamie Redding.

Table 1. Average DMI, CPI, Milk, ECM, and MUN/kg DMI

Item	Average ¹	Exps. 1 and 2 ²	Exp. 3 ³
DMI, lb/day	49.65	47.94	56.52
CPI, lb/day	8.45	8.14	9.61
Milk, lb/day	62.79	62.48	65.21
ECM ⁴ , lb./day	67.54	65.67 ⁵	—
MUN/kg DMI	—	.25 ⁵	.21 ⁶

¹Average for the 11 d observation period.

²Average for day samples taken for Exps. 1 and 2.

³Average for day samples taken for Exp. 3.

⁴ECM = energy-corrected milk.

⁵Calculated from composite sample values.

⁶Calculated from 12 hr values.

Table 2. Relationship among Quarters with Respect to Milk Composition

Item	Quarter				Composite
	RF	LF	RR	LR	
Fat, %	1.54 ^a	1.44 ^a	1.61 ^a	1.52 ^a	3.59 ^b
Protein, %	3.65 ^{ab}	3.68 ^a	3.68 ^a	3.63 ^{ab}	3.60 ^b
SNF, %	9.42 ^a	9.51 ^a	9.48 ^a	9.34 ^a	9.39 ^a
Lactose, %	4.99 ^a	5.04 ^a	5.00 ^a	4.94 ^a	4.98 ^a
SCC, *1000	62.00 ^{ab}	29.13 ^a	77.38 ^{ab}	134.63 ^b	63.25 ^{ab}
MUN, mg/dl	12.25 ^{ab}	12.48 ^a	12.45 ^a	12.49 ^a	12.06 ^b

^{a,b}Means within rows sharing different superscript letters differ ($P < 0.05$).

Table 3. Effect of Previous Sampling on MUN Concentration (mg/dL)

Quarter	Sampling Time, hr			
	2	4	6	8
RF	11.27	12.22 ^a	13.04	13.11
LR	–	12.81 ^b	–	–
RR	–	–	12.76	–
LR	–	–	–	13.07

^{a,b}Values within columns sharing different superscript letters differ ($P < 0.01$).

Table 4. Variation in Milk Composition over Time after Feeding¹

Item	Time Postfeeding, hr						Contrast ²
	2	4	6	8	10	12	
Fat, %	7.66	6.37	5.32	4.12	2.27	2.22	linear
Protein, %	3.06	3.26	3.44	3.62	3.93	4.00	linear
SNF, %	8.04	8.23	8.35	8.57	9.03	9.23	linear
Lactose, %	4.22	4.23	4.20	4.25	4.41	4.53	linear
SCC, *1000	956.38	438.88	1135.25	763.25	519.63	369.63	–
MUN, mg/dL	13.65	14.30	14.46	13.94	13.16	12.04	linear

¹Feeding time began approximately 30 min after AM milking.

² $P < 0.01$.

Table 5. Effects of Time after Feeding on Plasma Metabolites

Sampling Time	PUN ^{1a} , mg/dL	TAAN ² , mmol/L	Glu. ^{3b} , mg/dL
1	15.17	2.41	71.1
2	15.77	2.19	70.6
3	15.66	2.11	67.4
4	15.39	2.12	70.2
5	14.80	2.06	71.7
6	13.95	1.91	72.0
7	13.15	1.99	72.3
8	12.25	1.99	72.8
9	11.71	2.03	73.9
10	11.24	2.06	70.1
11	10.99	2.24	72.9
12	10.65	2.15	71.3
SEM	.25	.05	.84

¹Plasma urea nitrogen

²Total alpha amino acid nitrogen

³Glucose.

^aLinear contrast ($P < 0.01$).

^bQuadratic contrast ($P < 0.01$).

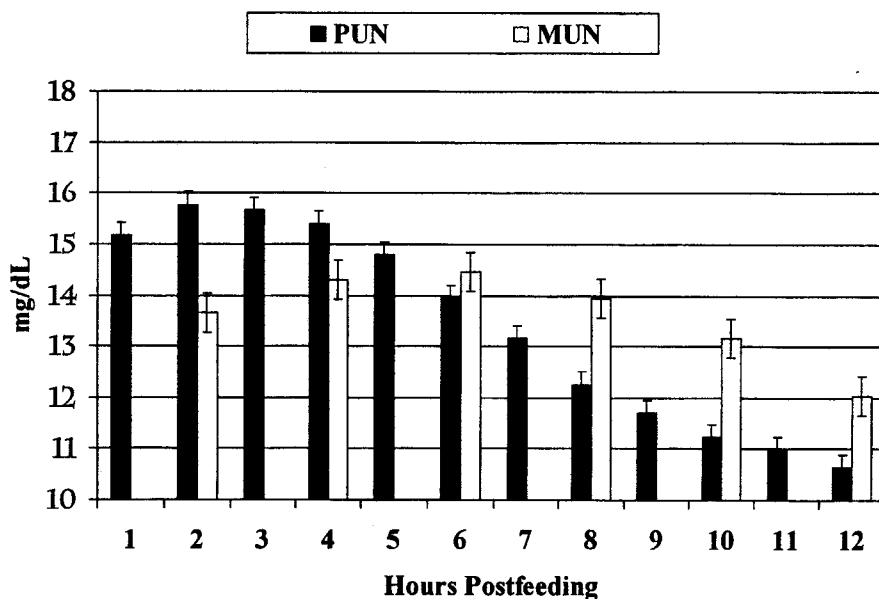


Figure 1. Effects of Time Postfeeding on MUN and PUN.

Dairy Day 2000

FACTORS AFFECTING DRY MATTER INTAKE BY LACTATING DAIRY COWS

M. J. Brouk and J. F. Smith

Summary

Feed intake is the single most critical factor of dairy production, and performance of dairy cattle can be enhanced or hindered by environmental factors that affect it. These environmental factors can be divided into physical and climatic conditions. On modern dairies, the physical factors may be of more concern. Modern facilities provide the cow with protection from the natural elements. However, these same facilities can enhance or hinder dry matter intake. Facilities should provide adequate access to feed and water, a comfortable resting area, and adequate protection from the natural elements. Critical areas of facility design related to feed intake include access to feed and water, stall design and surface, supplemental lighting, ventilation, and cow cooling. The total system should function to enhance cow comfort and intake. It is important to remember that choices made during construction of a facility will affect the performance of animals for the life of the facility, which is generally 20 to 30 yr. Producers, bankers, and consultants too often view the additional cost of cow comfort from the standpoint of initial investment rather than long-term benefit.

(Key Words: Facilities, Cows, Environmental Stress.)

Introduction

One of the keys to success in dairy production is to design and manage facilities to maximize the dry matter intake of dairy cattle. Intake is impacted by environmental and management factors. Environmental concerns include the physical facilities and climatic conditions to which the cattle are

exposed. Management factors include feeding, grouping, and cow flow patterns that may be influenced by facility design. The goal of the system should be to provide adequate cow comfort that includes: 1) adequate access to feed and water; 2) a clean and dry bed that is comfortable and correctly sized and constructed; 3) acceptable air quality; and 4) adequate protection from the natural elements.

Access to Feed and Water

4-Row vs 6-Row Barns

One of the critical decisions to make is the type of freestall barn to build. The most common types are either 4- or 6-row barns. Often the cost per cow or stall is used to determine which barn should be built. Table 1 illustrates the typical dimensions of the barns, and Table 2 demonstrates the effects of overcrowding on per-cow space for feed and water. Research indicated that feed bunk space of less than 8 inches per cow reduced intake and bunk space of 8 to 20 inches per cow resulted in mixed results. Even at a 100% stocking rate, the 6-row barn offers only 18 inches of feed-line space per cow. When overcrowding occurs, average feed-line space is reduced significantly. Four-row barns, even when stocked at 140% of the stalls, still provide more than 18 inches per cow of bunk space. In addition, when water is provided only at the crossovers, water space per cow is reduced by 40% in the 6-row barn compared to 4-row barns. Much of the current debate over the effect of 4- and 6-row barns on intake likely is related to presence or absence of management factors that either reduce or increase the limitations of access to feed and water in 6-row barns.

Feed Barrier Design

The use of self-locking stanchions as feed barriers is currently a debated subject in the dairy industry. Data reported in the literature are limited, and conclusions differ. One study (1996) reported that cows restrained in self-locking stanchions for 4 hr had milk production and dry matter intakes similar to those of cows not restrained. Other researchers observed similar results in another study. However, a third study reported similar intake but a 6.4 lb decrease in daily milk production when cows were restrained during a 4-hr period (9 AM to 1 PM) in the summer. Increases in concentrations of cortisol also were noted during the summer but not in the spring, indicating a greater amount of stress during the summer. All of these studies compared restraining cows for 4 hr to no restraint, and all animals were housed in pens equipped with headlocks. The studies did not compare a neck rail barrier to self-locking stanchions or address the effects of training upon headlock acceptance. Some have interpreted these results to mean that self-locking stanchions reduce milk production and only the neck rail barrier should be used. More accurately, the results indicate that cows should not be restrained for periods of 4 hr during the summer heat. The argument could be made that 4 hr of continuous restraint is excessive, and much shorter times (1 hr or less) should be adequate for most procedures. These studies clearly indicate that mismanagement of the self-locking stanchions, not the stanchions themselves, resulted in decreased milk production in only one of three studies but had no effect on intake in all three studies.

Another study compared lockups to neck rails in a 4-row barn under normal and crowded (130% of stalls) conditions. Results of the short-term study showed a 3 to 5% decrease in dry matter intake when headlocks were used. No differences were observed in milk production or body condition score. The overcrowding also reduced the percentage of cows eating after milking compared to no overcrowding. In this study, use of headlocks

reduced feed intake but did not affect milk production.

Freestall Design and Surfaces

Freestall Design

Cows must have stalls that are sized correctly. As early as 1954, research demonstrated increases in milk production when larger cows were allowed access to increased stall sizes. Today, construction costs often encourage producers to reduce stall length and width. This may reduce cow comfort and production. Cows will use freestalls that are designed correctly and maintained. Refusal of cows to utilize stalls likely is related to design or management of the freestall area. Table 3 provides recommendations for correctly sizing the stall. In addition, the stall should be sloped front to back, and a comfortable surface should be provided.

Freestall Surface Materials

Sand is the bedding of choice in many areas. It provides a comfortable cushion that conforms to the body of the cow. In addition, its very low content of organic matter reduces risk of mastitis. In many cases, it is readily available and economical. In some areas, it is not economical, and other producers may choose not to deal with the issue of separating the sand from the manure. Because 25 to 50 lb of sand are consumed per stall per day, it should be separated from manure solids to reduce the solid load on the manure management system. Producers choosing not to deal with sand bedding often choose from a variety of commercial freestall surface materials. Research has shown that when given a choice, cows show a preference for certain materials. Occupancy ranged from >50 to <20%. An increase in occupancy rate likely was influenced by the compressibility of the covering. Cows selected freestall covers that compressed to a greater degree over those with minimal compressibility. Sand and materials that compress likely will provide greater comfort, as demonstrated by cow preference.

Supplemental Lighting

Lactating Cows

Supplemental lighting has been shown to increase milk production and feed intake in several studies. One study reported a 6% increase in milk production and feed intake when cows were exposed to a daily photoperiod of 16 hr of light and 8 hr of dark (16L:8:) compared to natural photoperiods during the fall and winter months. Median light intensities were 462 lux and 555 lux for supplemental and natural photoperiods, respectively. Another study reported a 5% increase in feed intake when proper ventilation and lighting were provided. Other researchers reported a 3.5% increase without bST and 8.9% with bST when photoperiod was increased from 9.5-14 to 18 hr. Increasing daily photoperiod to 16-18 hr of light increased feed intake. Additional research showed that 24 hr of supplemental lighting did not result in additional milk production over 16 hr of light. These studies utilized different light intensities in different parts of the housing area. In modern freestall barns, the intensity varies greatly depending on the location of the light source. Thus, additional research is needed to determine the intensities required for different locations within pens to increase intake.

Another issue with lighting in freestall barns is milking frequency. Herds milked 3× cannot receive 8 hr of continuous darkness. This is especially true in large freestall barns housing several milking groups. In these situations, the lights may remain on at all times to provide lighting for moving cattle to and from the milking parlor. The continuous darkness requirement of lactating cows may be 6 hr according to one report. Thus, setting milking schedules to accommodate 6 hr of continuous darkness is recommended. The use of low intensity red lights may be necessary in large barns to allow movement of animals without disruption of the dark period of other groups.

Dry Cows

Dry cows benefit from a different photoperiod than lactating cows. Recent research showed that dry cows exposed to short days (8L:16D) produced more milk in the next lactation than those exposed to long days (16L:8D). An earlier study reported similar results. Based on these results, dry cows should be exposed to short days and then exposed to long days after calving.

Heat Stress

Effects of Heat Stress

Heat stress reduces feed intake, milk production, health, and reproduction of dairy cows. Missouri researchers reported that lactating cows under heat stress decreased intake by 6 to 16% compared to those in thermal neutral conditions. Arizona workers also observed that cows cooled during the dry period produced more milk in the subsequent lactation than cows that were not cooled. The cow environment can be modified to reduce the effects of heat stress by providing for adequate ventilation and effective cow cooling measures.

Ventilation

Maintaining adequate air quality can be accomplished easily by taking advantage of natural ventilation. Researchers showed that a 4/12 pitch roof with an open ridge resulted in lower afternoon respiration rates of cows that a reduced roof pitch or covering the ridge. They also observed that eave heights of 14 ft resulted in lower increases in respiration rates than shorter eave heights. Designing freestall barns that allow for maximum natural airflow during the summer will reduce the effects of heat stress. Open sidewalls, open roof ridges, correct sidewall heights, and the absence of buildings or natural features that reduce airflow increase natural airflow. During winter, it is necessary to allow adequate ventilation to maintain air quality while providing adequate protection from cold stress.

Another ventilation consideration is the width of the barn. Six-row barns are typically wider than 4-row barns. This additional width reduces natural ventilation. Summer ventilation rates are reduced 37% in 6-row barns compared to 4-row barns. In hot and humid climates, barn choice increases heat stress, resulting in lower feed intake and milk production.

Cow Cooling

During periods of heat stress, it is necessary to reduce cow stress by increasing airflow and installing sprinkler systems. The critical areas to cool are the milking parlor, holding pen, and housing area. First, these areas should provide adequate shade. Barns built with a north-south orientation allow morning and afternoon sun to enter the stalls and feeding areas and may not adequately protect the cows. Second, as temperatures increase, cows depend upon evaporative cooling to maintain core temperature. The use of sprinkler and fan systems to effectively wet and dry the cows will increase heat loss.

The holding pen should be cooled with fans and sprinkler systems, and an exit lane sprinkler system may be beneficial in warmer

climates. Holding pen time should not exceed 1 hr. Fans should move 1,000 sq ft/min per cow. Most 30- and 36-inch fans will move between 10,000 and 12,000 sq ft/min per fan. If one fan is installed per 10 cows or 150 sq ft, adequate ventilation should be provided. If the holding pen is less than 24 ft wide with 8-10 ft sidewall openings, fans can be installed on 6- to 8-ft centers along the sidewalls. For holding pens wider than 24 ft, fans are mounted perpendicular to the cow flow. Fans are spaced 6- to 8-ft apart and in rows spaced either 20 to 30 ft apart (36-inch fans) or 30 to 40 ft apart (48-in fan). In addition to the fans, a sprinkling system should deliver .03 gal water per sq ft of area. Cycle times generally are set at 2 min on and 12 min off.

Heat abatement measures in freestall housing should include feed-line sprinklers and fans to increase air movement. Sprinkling systems should deliver water similar to the holding pen system, except they should wet only the area occupied when the cow is at the feed bunk. The hair coat of the cow should become wet and then be allowed to dry prior to the beginning of the next wetting cycle. Fans can be installed over the feed-line to provide additional airflow and increase evaporation rate.

Table 1. Average Pen Dimensions, Stalls, Cows, and Allotted Space per Animal in 4-Row and 6-Row Barns

Barn Style	Pen Width	Pen Length	Stall per Pen	Cows per Pen	Per Cow		
					Area	Feedline Space	Water Space
	- ft -	- ft -	- no. -	- no. -	- sq ft -	- inches -	- inches -
4-Row	39	240	100	100	94	29	2.4
6-Row	47	240	160	160	71	18	1.5
2-Row	39	240	100	100	94	29	2.4
3-Row	47	240	160	160	71	18	1.5

Adapted from Smith et al., 2000. Relocation and Expansion for Dairy Producers. Kansas Cooperative Extension Service, MF2424, page 8.

Table 2. Effect of Stocking Rate on Space per Cow for Area, Feed and Water in 4- and 6-Row Barns

Stocking Rate, %	Area, sq ft/cow		Feedline Space, linear inches/cow		Water Space, linear inches/cow	
	4-Row	6-Row	4-Row	6-Row	4-Row	6-Row
100	28.5	21.3	29	18	2.4	1.5
110	25.9	19.4	26	16	2.2	1.4
120	23.8	17.8	24	15	2.0	1.3
130	21.9	16.4	22	14	1.9	1.1
140	20.4	15.2	21	13	1.7	1.1

Adapted from Smith et al., 2000. Relocation and Expansion for Dairy Producers. Kansas Cooperative Extension Service, MF2424, page 8.

Table 3. Freestall Dimensions for Cows of Various Body Weights

Body Weight	Free Stall Width	Side Lunge	Forward Lunge ^a	Neck Rail Height above Stall Bed	Neck Rail and Brisket Board Bed, Distance from Alley Side of Curb
– lb –	– inches –	– inches –	– inches –	– inches –	– inches --
800-1,200	42 to 44	78	90 to 96	37	62
1,200- 1,500	44 to 48	84	96 to 102	40	66
Over 1,500	48 to 52	90	102 to 108	42	71

^aAn additional 12 to 18 inches in stall length are required to allow the cow to thrust her head forward during the lunge process.

Adapted from Dairy Freestall Housing and Equipment, 1997. 6th Edition. Midwest Plan Service, Publication MWPS7, page 2. Iowa State University, Ames.

Dairy Day 2000

KEEPING COWS COOL

J. F. Smith, J. P. Harner¹, and M. J. Brouk

Summary

Heat stress occurs when a dairy cow's internal heat load is greater than her capacity to lose unwanted heat to the environment. Effects of heat stress include: increased respiration rate, increased water intake, increased sweating, decreased dry matter intake, slower rate of feed passage, decreased blood flow to internal organs, decreased milk production, and poor reproductive performance. Lower milk production and reproductive performance cause economic losses to dairy producers. The ordered priorities for reducing heat are: increasing water availability; providing shade in the housing areas (both dry and lactating cows) and holding pen; reducing walking distance to the parlor; reducing time in the holding pen; improving holding pen ventilation and freestall ventilation; adding cooling for the holding pen and exit lane; cooling close-up cows (3 wk before calving); cooling housing for fresh and early-lactation cows; and cooling housing for mid- and late-lactation cows.

(Key Words: Heat Stress, Cooling Techniques.)

Water Availability

Providing access to water during heat stress should be the first step. Lactating dairy cattle typically require between 35 and 45 gallons of water per day. Studies done in climatic chambers indicate that water needs increase 1.2 to 2 times when cows are under heat stress. A water system needs to be

designed to meet both peak demand and daily needs of the dairy. Making water available to cows leaving the milking parlor will increase water intake by cows during heat stress. Access to an 8-ft water trough is adequate for milking parlors with #25 stalls per side. When using dry-lot housing, we recommend placing water troughs at two locations using the following formula to calculate the required tank perimeter. Group size $\times 0.15 \times 2 =$ tank perimeter in feet. In freestall housing, one waterer or 2 ft of tank perimeter is adequate for every 15 to 20 cows. An ideal situation would be to have water available at every crossover between feed and resting areas. A minimum of two watering locations per pen is needed.

Shades

Providing shade in housing areas and the holding pen is the second step. Cows housed in drylot or pasture situations should be provided with solid shade. Florida researchers found that cows housed with shade produced more milk and had greater conception rates than nonshaded cows. Natural shading provided by trees is effective, but most often shades are constructed from solid steel or aluminum. Providing 38 to 48 sq ft of solid shade per mature dairy cow is adequate to reduce solar radiation. Shades should be constructed at a height of at least 14 ft with a north-south orientation to prevent wet areas from developing under them. More porous materials such as shade cloth or snow fence are not as effective as solid shades.

¹Department of Biological and Agricultural Engineering.

Methods to Cool Cows

Several trials have evaluated different cooling systems in a wide variety of climates. Everything from high-pressure misters to low-pressure sprinklers or soakers have been used to apply water to cows along with fan systems to aid in the evaporation of water off the cow's back or out of the air around the cow. As humidity increases in the environment, the ability to evaporate water decreases. In general, low-pressure sprinkler or soaker systems to wet cows along with fans can be used in any climate to cool cows. We can witness the effectiveness of these systems by visiting the local pool on a hot windy day. The children will leave the pool and become cold as the water evaporates off their skin. Just watch these children develop goose bumps as they search for their towels. Once they dry off, they become warm and jump back in the pool to start the same cycle again. The same technique is used in cooling dairy cattle by wetting cows intermittently. Remember that high-pressure systems cool the air around the cow and work best in very arid climates. When we combine low-pressure and high-pressure systems, we run the risk of reducing the ability to evaporate moisture off the cows' back. Unless you are producing milk in an arid climate, a low-pressure system is probably the most economical and practical way to cool cows.

Holding Pen and Exit Lane Cooling

The holding pen is where dairy cows probably experience the most heat stress. Arizona researchers concluded that when cows were cooled in the holding pen, milk production was increased 1.7 pounds per day during the summer. To make this improvement, low-volume sprinklers are used to wet cows, and fans are used to hasten evaporation of the water off their backs. Fans should be operated continuously providing a minimum of 1,000 cu ft per cow. Fans should be mounted overhead at a 30° angle from vertical, so that the air will blow downward. Fans of 36- to 48-inch diameter used are most commonly. Fans typically are spaced 6 to 8 ft side-to-side. The distances between rows of fans are 20 ft for 30- and 36-inch fans and

40 ft for 48-inch fans. Water can be sprayed onto the cows using a PVC grid of 360° nozzles. Water is applied for 1 min every 6 min.

Cows can be cooled as they exit the parlor to provide an additional 15 to 25 min of cooling per milking. Typically, three to four nozzles are installed in the exit lane, with a delivery of approximately 8 gallons of water per minute at 35 to 40 PSI. The nozzles are turned on and off with an electric eye or wand switch as the cow passes under the nozzles. If properly installed, nozzles will wet the top and sides of the cow, but the udder will remain dry so water does not wash off postmilking teat dips.

Freestalls

Freestall housing should be constructed to provide good natural ventilation. Sidewalls should be 14 ft high to increase the volume of air in the housing area. They should be 75 to 100% open. Fresh air should be introduced at the cow's level. Curtains on the sides of freestall barns allow greater flexibility in controlling ventilation. Because warm air rises, steeper sloped roofs provide upward flow of warm air. However, roofs with slopes steeper than a 6/12 pitch prevent incoming air from dropping into the area occupied by the cows. Roofs with slopes less than 4/12 may cause condensation and higher internal temperatures in the summer. Roof slopes for freestall housing should range from 4/12 to 4/16. Providing openings in end walls and alley doors improves summer ventilation. Gable buildings should have a continuous ridge opening to allow warm air to escape. The ridge opening should be 2 inches for each 10 ft of building width. The distance between naturally ventilated buildings should be a minimum of 1.5 to 2 times the building width.

Adding fans and a sprinkler system provides additional cooling in freestall areas. Freestall bedding must not become wet. Typically, a sprinkler system or soaker system can be located over the feed-line lockups. Fans can be used over the freestalls, lockups, or both to increase evaporation of

water off the cow's back. Water is applied for 3 min every 15 min. These spray and fan systems can be turned on and off with a thermostat set at 70 to 75°F.

Which Groups of Cows Do I Cool First?

A commonly asked question is which cows should be cooled first? The short answer is that all lactating and dry cows should be cooled, if possible. All lactating cows will respond to cooling during heat stress. With a limited budget, a choice of which group of cows to cool is required. The first group to cool should be the close-up cows. Dry matter intake before calving is critical to ensure that the upcoming lactation is successful. Cows consume less dry matter during heat stress. The second group to be cooled should be the fresh and early-lactation cows. These cows are approaching their peak daily milk production. For every pound of peak daily milk yield that is lost, 250 pounds of milk production will be lost over the entire lactation. It is not uncommon for producers in Kansas to lose 10 pounds of

peak milk yield during heat stress when cows are not cooled. That is equivalent to 2500 pounds of milk over the lactation. Once early-lactation cows have been cooled, the mid- and late-lactation cows should be cooled.

Where Do I Start?

With a limited budget, start with step 1 and proceed through step 9: 1) increasing water availability; 2) providing shade in housing areas of dry and lactating cows and in the holding pen; 3) reducing walking distances to the parlor; 4) reducing time in the holding pen; 5) improving ventilation in the holding pen and freestall area; 6) adding cooling systems in the holding pen and its exit lanes; 7) cooling close-up cows during 3 wk before expected calving date; 8) cooling fresh cows and those in early lactation; and 9) cooling mid- and late-lactation cows. Starting with the basics and working over time to cool all the cows on your dairy will pay big dividends. Good luck keeping your cows cool during summer!

Dairy Day 2000

ANESTRUS IN LACTATING DAIRY COWS BEFORE OVULATION SYNCHRONIZATION

*J. S. Stevenson, J. A. Cartmill,
S. E. Zarkouny, and B. A. Hensley¹*

Summary

The incidence of anestrus in dairy cattle prior to first inseminations carried out after a minimum of 60 days postpartum ranged from 4 to 58% in first-lactation cows and 14 to 50% in older cows. Dairy cows with more days in milk, older than 2 years, and in better body condition (probably reflective of greater postpartum dry matter intakes) were more likely to cycle than thinner cows. Cows that were not cycling before the first week of insemination conceived at lower rates and took longer to become pregnant.

(Key Words: Body Condition, Cows, Anestrus.)

Introduction

Most mammals naturally undergo a variable period of anestrus following parturition. This period is referred to as a lactational or postpartum anestrus. Various factors contribute to the duration of this period, including age or lactation number, dry matter intake, body condition, milking frequency, and overall health. The most prolonged intervals to normal postpartum ovarian activity and onset of estrous cycles are observed in suckled cows, because multiple suckling bouts and continued cow-calf interactions prevent reestablishment of necessary pituitary hormone secretions (i.e., luteinizing hormone) to support follicular maturation.

Most studies have indicated that cows milked twice daily generally ovulate for the first time after calving sometime between 15 and 30 days in milk. As frequency of milking increases, the interval to first ovulation may increase slightly, but in all cases, the interval to first estrus is more prolonged than the interval to first ovulation. A high percentage of cows fail to show any sexual behavior (estrus) prior to first ovulations, but nearly all cows display estrus by the third ovulation.

Because of the preceding knowledge about dairy cows, most have considered anestrus not to be a limiting factor in achieving pregnancies. However, in more recent times, where cows are milked 3× daily and bST is used nearly universally, cows are more likely to carry less body condition into the dry period. Therefore, the potential exists for cows to experience more prolonged periods of anestrus.

Nutrients are used by cows according to an established priority. The first priority is maintenance of essential body functions to preserve life. Once that maintenance requirement is met, remaining nutrients accommodate growth. Finally, lactation and the initiation of estrous cycles are supported. Because older cows have no growth requirement, nutrients are more likely to be available for milk synthesis and estrous cycle initiation. Because of this priority system, young, growing cows generally produce less milk and are anestrus longer after calving. As a consequence, one might expect these

¹The authors are indebted to Duane Meier (Meier Dairy, Palmer, KS) and Steve Ohlde (Ohlde's Dairy, Linn, KS) for the use of their cattle in conducting these studies.

factors to influence the ability of the cows to initiate estrous cycles early after calving.

The objective of this collection of studies was to determine the incidence of anestrus in dairy cows prior to initiating various programmed breeding protocols that attempt to synchronize ovulation before first artificial inseminations.

Procedures

In the last 3 years, we have studied more than 1300 dairy cows on three dairy farms. As part of those studies, we have estimated the cycling status of these cows based on blood samples that were collected before synchronization of estrus, ovulation, or both. Blood samples were collected at least twice between 0 and 19 d before PGF_{2α} was administered on Monday of the insemination week and later assayed for concentrations of progesterone. This period corresponded to 40 to 83 days in milk when body scores also were measured (1 = thin and 5 = fat).

Cows were classified as anestrus when serum concentrations of progesterone were <1 ng/ml in all samples collected prior to the insemination week. If any one of several blood samples collected contained progesterone >1 ng/ml, these cows were considered to have initiated estrous cycles prior to the insemination week.

Results and Discussion

Table 1 summarizes the results of these studies. Two studies were conducted in non-summer months, and the third during a hot summer in Kansas (1998). One of these herds was milking 3× daily, and all herds' rolling DHI averages for milk exceeded 20,000 lb.

In the first study of 678 cows, the average percentage of cows cycling before timed AI (TAI) was 82% (Table 1). In the first-lactation, 2-year-old cows, cycling percentage was lower in one herd than in the second herd, whereas no difference in cycling percentages

were detected between herds for older cows. Body condition scores assessed at time of blood sampling averaged 2.3. Cows in better body condition were more likely to be cycling than thinner cows. Cows with more days in milk at the blood-sampling times also were more likely to be cycling.

In the second study of 251 cows in one herd where cows were milked 3× daily, the percentage of cows cycling was less at 44% (Table 1). Again, body condition averaged about 2.3. Younger and thinner cows were less likely to be cycling. In fact, as body condition increased by 0.5 units, the percentage of cows cycling increased by 24%. Milk yield (150-d energy-corrected milk) had no influence on cycling percentages.

In the last study of 385 cows in three herds during the summer, the percentage of cows cycling was 84% (Table 1). In this study, lactation number did not affect cyclicity, but body condition (average of 2.4) was very important. For every 0.5 unit increase in body condition for cows in the study, cyclicity increased by 7.2%.

Subsequent first-service pregnancy rates (measured at days 27-29 after insemination) in dairy cows that were either cycling or anestrus prior to the insemination week are summarized in Table 2. In nearly every comparison, pregnancy rates were numerically less in those cows that were anestrus prior to insemination. The exceptions were those anestrus cows treated with progesterone (via an intravaginal progesterone-releasing device or CIDR-B) and anestrus cows treated with the Ovsynch protocol during the summer.

The important point learned from these studies was that cows not cycling by the end of the volunteer waiting period conceived at lesser rates and took longer to eventually get back in calf (data not shown). In each case, body condition was a very important predictor of when cows began estrous cycles after calving.

Table 1. Estimates of Cycling Status of Lactating Dairy Cows Producing More than 20,000 lb of Milk before the Onset of First AI

Season	Herd	No. of Cows	Days in Milk when Blood Sampling Occurred	Lactation Number	
				1	2+
----- % cycling -----					
Not summer	1	284	48-68	88	86
	2	394	40-60	72	87
Not summer	1	251	47-67	42	50
	1	66	63-83	96	85
Summer	2	198	57-77	83	87
	3	121	56-76	77	86

Table 2. First-Service Pregnancy Rates of Lactating Dairy Cows Based on Their Cycling Status Prior to First Insemination

Season	Treatments	Cycling Status	
		No	Yes
----- % pregnancy rates (no. of cows) -----			
Not summer ¹	Ovsynch	28 (54)	47 (36)
	Ovsynch + CIDR	62 (50)	54 (41)
Not summer ²	Ovsynch	22 (37)	36 (189)
	PGF + Ovsynch	33 (47)	43 (186)
	2 × PGF	20 (44)	37 (197)
Summer ³	Ovsynch	36 (31)	33 (176)
	Select Synch	13 (31)	19 (187)

¹Ovsynch = injections of GnRH 7 days before and 48 hr after PGF_{2α}. Ovsynch + CIDR (Ovsynch + a progesterone-releasing device placed in the vagina for 7 days beginning at the first GnRH injection and removed when PGF_{2α} was injected. In both cases, one AI was administered at 16 to 20 hr after the second GnRH injection.

²Ovsynch = as described above. PGF + Ovsynch = one injection of PGF_{2α} given 12 days before the Ovsynch protocol. 2 × PGF = injections of PGF_{2α} given 12 days apart and one injection of GnRH given 48 hr after the second PGF_{2α} injection. In all cases, one AI was administered at 16 to 20 hr after the second GnRH injection.

³Ovsynch = as described above. Select Synch = injection of GnRH 7 days before PGF_{2α} and cows inseminated after detected estrus.

Dairy Day 2000

EMBRYO SURVIVAL IN LACTATING DAIRY COWS

*J. S. Stevenson, J. A. Cartmill,
S. E. Zarkouny, and B. A. Hensley¹*

Summary

Rates of embryo survival in lactating dairy cows were assessed in three separate studies. Based on pregnancy diagnoses 27 to 29 days after timed inseminations, survival to days 40 to 50 or day 57, depending on the study, varied from 9 to 88% in cows that were not cycling before insemination compared to 57 to 90% in cows that were cycling. Previously anestrous cows had lower rates of survival. In one study, supplementing cows with progesterone before insemination improved embryo survival.

(Key Words: Embryo Survival, Cows, First AI.)

Introduction

Reproductive failure of cows results in financial liabilities to dairy producers. These liabilities include greater breeding costs, greater involuntary culling rates, and increased maintenance costs. Embryo and fetal deaths following insemination are major components of these losses.

Previous research indicates that about 90% of the eggs are fertilized, and average calving rates are 55% following single inseminations. Based on those estimates, the rate of embryonic and fetal mortality is 38%. Of this total loss, 70 to 80% probably is sustained between days 8 and 16 after AI, 10% between days 16 and 42, and 5 to 8% between day 42 and term. In so-called

“repeat breeders,” fertilization and embryo losses are even greater.

Current studies of pregnancy losses in dairy cows located in Ireland, where cows produce about 50% as much milk as U.S. dairy cows, seem to substantiate the losses cited above. Based on one U.S. study of dairy cows annually producing in excess of 24,000 lb of milk, pregnancy losses are much greater. These losses likely are related to the greater milk-producing capacity of our cows. Of pregnancies diagnosed on day 28 after AI (using transrectal ultrasonography), survival rates of the pregnancies were 89.5% to day 42; 83.2% to day 56; 81.5% to day 70; and 79.8% to day 98.

The purpose of the current survey of three Kansas dairy farms was to estimate the amount of pregnancy loss that was occurring after first AI services.

Procedures

Three studies were conducted in which first postpartum inseminations were programmed with various ovulation synchronization protocols.

Study 1 consisted of cows inseminated after the Ovsynch protocol (injections of GnRH given 7 days before and 48 hr after PGF_{2α} with timed AI [TAI] 16 to 20 hr after the second GnRH injection) compared to cows inseminated after the Select Synch protocol (injection of GnRH 7 days before PGF_{2α} and inseminations performed after

¹The authors are indebted to Duane Meier (Meier Dairy, Palmer, KS) and Steve Ohlde (Ohlde's Dairy, Linn, KS) for the use of their cattle in conducting these studies.

visually detected estrus). This study was conducted during the summer of 1998 on two dairy farms and during the summers of 1998 and 1999 on a third dairy farm. Pregnancy was diagnosed once between 27 to 29 days after AI (transrectal ultrasonography) and reconfirmed by palpation between 40 and 50 days.

Study 2 (winter and spring of 1997-1998) consisted of cows inseminated after the Ovsynch protocol compared to those inseminated after the same protocol but with a CIDR (controlled internal drug release: a progesterone-releasing device) inserted intravaginally at the time of the first GnRH injection and removed 7 days later when PGF_{2α} was administered (Ovsynch + CIDR). Inseminations were carried out 16 to 20 hr after the second GnRH injection. Pregnancy was diagnosed (transrectal ultrasound) on day 29 after TAI and again at day 57.

Study 3 (fall, winter, and spring of 1997-1999) consisted of cows inseminated after the Ovsynch protocol compared to: 1) those inseminated after the same protocol but with one injection of PGF_{2α} 12 days before the cows received the first GnRH injection of the Ovsynch protocol (PG + Ovsynch), and 2) those inseminated after having received two injections of PGF_{2α} 12 days apart and one GnRH injection 48 hr after the last of two PGF_{2α} injections (2×PG12). In all three protocols, cows were inseminated 16 to 20 hr after the second or only GnRH injection. Pregnancy was diagnosed once at 27 to 29 days after AI (transrectal ultrasound) and reconfirmed by palpation between 40 and 50 days.

Results and Discussion

Embryo survival for Study 1 is summarized in Table 1. Of cows diagnosed pregnant by ultrasound on days 27 to 29, fewer ($P=0.07$) embryos survived to days 40 to 50

(palpated pregnancy diagnosis) after the Ovsynch than Select Synch protocols. Cows identified to be not cycling before the onset of the breeding protocols had less ($P<0.05$) embryo survival than cycling cows. These results may indicate that noncycling cows in both treatments were induced successfully to ovulate and subsequently conceive, but had a decreased ability to maintain pregnancy beyond 27 to 29 days.

In Study 2, embryo survival was enhanced ($P<0.05$) greatly by treatment of cows with progesterone (Table 1) in conjunction with the Ovsynch protocol. In this study, embryo survival was not affected by previous cycling status.

Embryo survival in Study 3 is illustrated in Table 1. Rates of embryo survival tended ($P=0.09$) to be affected by an interaction of treatment and cycling status. Although cycling cows had numerically better embryo survival in all treatments, survival in the 2×PG12, noncycling cows apparently was reduced. These results indicate that the noncycling cows possibly benefitted from the first GnRH injection given 10 days before TAI in both groups treated with the Ovsynch protocol.

The average survival rates were 53% in cows not cycling before insemination and 77% for cows that were cycling. These are considerably less than those reported elsewhere (approximately 83%). It is alarming to see such losses occurring in Holstein cows after they have conceived. Causes for these losses are unknown but may include insufficient energy, too much crude protein (particularly rumen-degradable protein that elevates blood and milk urea nitrogen and ammonia), and(or) insufficient luteal function (reduced concentrations of progesterone in blood serum of cows). We plan to investigate further if insufficient progesterone is a primary cause for embryo losses in lactating dairy cows.

Table 1. Embryo Survival after d 27 to 29 of Pregnancy in Lactating Dairy Cows

Treatments	Cycling Status ¹		Probabilities		
	No	Yes	Treatment	Cycling	T×C
	% embryo survival ⁵ (no. of pregnancies diagnosed on days 27-29)				
Study 1 ²	20 (15)	63 (95)			
Ovsynch	9 (11)	57 (58)	0.07	0.03	0.44
Select Synch	50 (4)	73 (37)			
Study 2 ³	61 (49)	78 (37)			
Ovsynch	50 (16)	63 (16)	0.02	0.20	0.56
Ovsynch + CIDR	67 (33)	90 (21)			
Study 3 ⁴	67 (33)	73 (223)			
Ovsynch	88 (8)	70 (70)	0.11	0.47	0.09
PG + Ovsynch	69 (16)	76 (80)			
2×PG12	44 (9)	74 (73)			

¹Cows with elevated concentrations of progesterone (>1 ng/ml) in blood serum samples collected before insemination were cycling and those with progesterone <1 ng/ml were anestrus.

²Ovsynch = injections of GnRH 7 days before and 48 hr after PGF_{2α}. Inseminations were conducted 16 to 20 hr after the second GnRH injection. Select Synch = injection of GnRH 7 days before PGF_{2α} and cows inseminated after detected estrus.

³Ovsynch = as described above. Ovsynch + CIDR (Ovsynch + a progesterone-releasing device placed in the vagina for 7 days beginning at the first GnRH injection and removed when PGF_{2α} was injected. In both cases, one AI was administered at 16 to 20 hr after the second GnRH injection.

⁴Ovsynch = as described above. PG + Ovsynch = one injection of PGF_{2α} given 12 days before the Ovsynch protocol. 2×PG12 = injections of PGF_{2α} given 12 days apart and one injection of GnRH given 48 hr after the second PGF_{2α} injection. In all cases, one AI was administered at 16 to 20 hr after the second GnRH injection.

⁵Embryo survival after days 27 to 29 (via ultrasonography) until cows were palpated for pregnancy diagnosis between 40 and 50 days. Survival in Study 2 (Ovsynch vs Ovsynch + CIDR) represent those from day 29 to day 57 (via ultrasonography).

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BIOLOGICAL VARIABILITY AND CHANCES OF ERROR

Variability among individual animals in an experiment leads to problems in interpreting the results. Although the cattle on treatment X may have produced more milk than those on treatment Y, variability within treatments may indicate that the differences in production between X and Y were not the result of the treatment alone. Statistical analysis allows us to calculate the probability that such differences are from treatment rather than from chance.

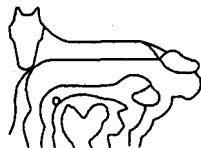
In some of the articles herein, you will see the notation " $P < .05$ ". That means the probability of the differences resulting from chance is less than 5%. If two averages are said to be "significantly different", the probability is less than 5% that the difference is from chance or the probability exceeds 95% that the difference resulted from the treatment applied.

Some papers report correlations or measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one trait gets larger, the other gets smaller). A perfect correlation is one (+1 or -1). If there is no relationship, the correlation is zero.

In other papers, you may see an average given as $2.5 \pm .1$. The 2.5 is the average; .1 is the "standard error". The standard error is calculated to be 68% certain that the real average (with unlimited number of animals) would fall within one standard error from the average, in this case between 2.4 and 2.6.

Using many animals per treatment, replicating treatments several times, and using uniform animals increase the probability of finding real differences when they exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals. In all the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

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The Livestock and Meat Industry Foundation, Inc. (LMIF) has a unique approach for promoting the growth and development of the livestock and meat industry. The Livestock and Meat Industry Foundation, Inc. is a 501(c)(3) non-profit charitable foundation that has nearly thirty years of experience supporting animal agriculture.

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1. Annually provides over \$100,000 for scholarships and student enrichment opportunities to students in Animal Science and Industry at Kansas State University.
2. Funds Dairy, Poultry, Livestock, Meats, Wool, Horse and Dairy Products Judging Teams.
3. Provided over \$500,000 for equipment and supplies for the Weber Hall renovation project.
4. Solicited industry funds for initial research on frozen meat and related marketing studies.
5. Provided funds for the segregated early weaning (SEW) facilities at KSU.
6. Arranged a gift from the Rannells sisters of 2,056 acres of rangeland and purchased 620 adjoining acres to be used for range and beef cattle research. The 2,676-acre tract located along Highway 177 south of Manhattan is known as the Hilas Bay Rannells Flint Hills Prairie Preserve.

How can I become a member?

All contributors become members of the LMIF. Gifts of cash, property, livestock, grain, machinery, life insurance, IRA's, trusts and other methods of giving can be explored. Trusts are a great investment for the donor and the LMIF. A trust pays the donor for their lifetime with the remainder going to LMIF at death. Proceeds are used as the donor designated. If you are interested, please write and we will be glad to explain how a trust works, and show you how charitable giving can have a positive impact in estate planning.

Who controls and distributes these funds?

The board of directors of the Livestock and Meat Industry Foundation is responsible for allocating LMIF funds according to donor directions. All funds are managed by the KSU Foundation for investment purposes and donors receive credit for their contribution from the LMIF and KSU Foundation.

For more information on how you can be a part of this charitable foundation contact:

Dee W. James, Executive Vice President
The Livestock and Meat Industry Foundation, Inc.
134 Weber Hall - KSU
Manhattan, KS 66506-0201
(785) 532-1226

Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Manhattan 66506
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