A Case Study on a Dairy With Herd-wide Diarrhea and Reduced Milk Production

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Abstract

The objective of this study was to discover the cause of a major diarrhea outbreak and fifteen pound decrease in milk production that simultaneously took place in a dairy herd located in California's central valley. Throughout the duration of the problem there were five primary areas considered to be potential causes. These potential causes included silage quality, disease, water quality, almond hulls containing high levels of mycotoxins, and feed ration issues. The study used data from four different silage piles, each having different issues. Among these were issues of poor fermentation, low moisture content, high ash levels, and poor ensiling. Fecal, blood, and water samples were collected to test for diarrhea causing diseases such as salmonella and Bovine Viral Diarrhea Virus (BVD). Further analyses were performed on the water to test for high salinity, nitrate, and heavy metals. Along with these two tests, a necropsy was performed on an infected cow to locate any indication of disease or abnormality within the animal's internal organs or blood. Following the necropsy, BCS and fecal scoring was administered to 400 and 420 animals respectively. These scorings were used to gauge the overall condition of the herd. Following the scorings a rumenocentisis was performed on nine animals to determine an average rumen pH level throughout the herd and whether or not there was a presence of sub-acute ruminal acidosis (SARA). The last potential cause analyzed was the feed. Feed issues included extreme mycotoxin levels in a portion of the almond hulls, sorting and particle size, as well as a possible poor balance of energy and protein in the ration. Unfortunately, none of these causes were singled out as the primary problem in the herd. Conducting these tests did however allow us to determine deficiencies within our ration and silage. The final conclusion after eleven weeks of searching was that the dairy encountered a perfect storm of several destructive events occurring at once. These events negatively impacted the rumen's ability to digest feed properly, which resulted in the herd-wide diarrhea and reduced

milk production. Further studies on this case may produce a single specific cause that may help prevent its reoccurrence in the future.

Introduction

This study was a response to diarrhea and milk production problems in the herd that spanned a period of eleven weeks. The dairy is a Holstein herd milking 1,350 cows with an original average milk production during the month of December at 72lbs of milk per cow per day. During the eleven-week crisis, milk production dropped to an average of 55lbs and fluctuated between that number and the low 60s. Throughout the duration of the problem, nearly 80% of the herd was experiencing loose manure at any given time. Initially, all cows showing symptoms received some form of bolus intended to halt the diarrhea and get their stomachs back to normal. When the boluses did not show significant results, dozens of samples were taken from fecal matter, blood, rumen, silage, and the ration. Aside from the reduced milk production and widespread diarrhea, the problem was taking a huge toll on the financials of the dairy. In order to remain in business, it was imperative for the dairy to fix the problem and return the herd to normal. Throughout the eleven weeks, various potential causes were analyzed in depth do determine their affects. Through this process we were able to discover many areas of improvement as well as return the herd back to full health.

Literature Review

Salmonella

Salmonella is an infectious disease that is ingested by an animal. The bacteria are most commonly found in fecal matter, contaminated feeds, saliva and nasal secretions in water, and by calves through the consumption of milk or colostrum. It is often difficult to detect which cows are shedding the bacteria and which cows are actually infected because the number of harmful bacteria coming from each animal can be equal. While the primary carrier on a dairy is fecal matter from cows shedding the bacteria, other carriers include various animals that may be seen on a dairy such as birds, dogs, and flies (McGuirk and Peek, 2003).

While the original cause of salmonella in a herd is often from other animals, it can live in the environment just as easy. McGuirk and Peek (2003) found that given the proper conditions, salmonella bacteria replicate roughly every 30 minutes. Not only does salmonella replicate quickly, in the proper environment it can survive 4 to 5 years. Once in the environment, the bacteria can further be spread to crops. Farmland that is irrigated or fertilized with contaminated manure or wastewater may produce an infected crop. Though a majority of the time the bacteria are killed during harvesting and processing, there is still a chance of salmonella contamination in crops such as forages.

Cross-contamination is a major issue when dealing with salmonella in a herd. Aside from contamination through feces and water, contact also plays a huge role. Things such as medication equipment, nose tongs, calf nipples, farm equipment, and clothing are potential carriers of salmonella. Because of the way salmonella is transferred, outbreaks are more common in larger herds and herds that have regular influxes of cows coming to and leaving from the dairy. Salmonella will also have a higher chance of spreading in herds that are poorly maintained in terms of cleanliness, especially in corrals and commodity areas.

There are several prominent signs of salmonella in a dairy herd as well as various treatments. The most common clinical symptoms of salmonella include an increased temperature (Pyrexia), reduced feed intake, decreased milk production, dehydration, and diarrhea. Cows showing symptoms of dehydration and diarrhea often require treatments that include IV treatment, pumping of their stomachs with fluids, and electrolyte supplementation. Other medical treatments for cows with salmonella include probiotics and antibiotics. Cows to keep a particularly close eye on are close-up cows and fresh cows. Salmonella often occurs near calving because of the lowered feed intake and immunity. The environment within the rumen at this stage of the cow's life is prime growing-grounds for salmonella bacteria. Monitoring these cows as well as immediate treatment will help limit the spread of salmonella throughout the herd.

In order to eliminate or prevent salmonella in a herd, proper testing must be done. There are several different test methods used to test for a presence of the bacteria. Fecal samples involve collecting random samples from suspected animals or groupings. When testing for an entire group, samples should be collected from at least 20% (Mcguirk and Peek, 2003). These samples are then sent to the lab to be analyzed. Testing for salmonella via environmental or feed samples is often more difficult and requires a lab with experience in testing for the specific bacteria. Feed samples are easily collected and transported to the lab but often require refrigeration. Environmental samples are collected by using drag swabs and require special transport media and must be delivered to the lab within six hours. By conducting the proper tests and taking necessary precautions, salmonella can be detected and prevented.

Bovine Viral Diarrhea Virus

Bovine Viral Diarrhea Virus (BVD) is a disease in cows and calves that primarily affects reproduction but also results in diarrhea, pneumonia, and immuno-suppression (Navarre, 2006). Typically, BVD will not develop in a herd that does not already have it. The main causes of BVD include new cows or calves coming into the herd, any animals from the herd that temporarily leave the dairy, or through the purchase of uninfected pregnant cows or heifers that are carrying a calf that is infected. Animals in the herd that should be tested to prevent an infection of BVD include all calves, bulls, replacement heifers, and cows that have not had their calves tested (Grein, 1995). Vaccines can be given along with these tests in order to prevent BVD. However, vaccinations will not get rid of already present cases of BVD.

Calves and cows are each affected differently by BVD. Calves tend to face similar issues such as diarrhea, pneumonia, and immunity problems, but BVD may also result in Bovine Respiratory Disease Complex in calves (Navarre, 2006). Furthermore, calves subjected to the disease face the risk of reproduction issues once they reach breeding age. Cows very rarely show signs of pneumonia or suppressed immunity, but rather show the majority of symptoms in reproduction. Cows with BVD tend to face problems of infertility, embryonic death, abortions, stillbirths, and calves with birth defects. While these are all huge and costly problems, the worst symptom of BVD is persistently infected (PI) calves

(Navarre, 2006). A PI is the result of an infected fetus that becomes a calf. The calf can immediately become sick or appear totally healthy. This calf will continue to shed the virus throughout its life, exposing the rest of the herd to the disease. The result of this is a herd-wide problem of BVD if the carriers are not immediately culled and preventative measures are taken.

Body Condition Score (BCS)

Body condition scoring involves assigning a numerical value to a cow, between 1 and 5, in order to gauge her overall health in terms of size. A score of 1 indicates a very skinny cow, while a 5 indicates a cow that is overweight. This scoring provides a useful tool in determining how the cow is utilizing her energy and whether or not rations should be changed accordingly. Each stage of lactation has a varying ideal BCS, and it is essential to adjust the ration in each group of cows to maintain these benchmark numbers throughout their lactation and dry-period.

Table 1: Ranges of Ideal Body Condition Scores (Kellogg)

Stage of Lactation	Score
Dry	3.5-4.0
Close-up(1st Lactation)	3.5
Fresh (1 month)	2.5-3.0
Mid-lactation	3.0
Late Lactation	3.25-3.75
Close-up (2nd+ Lactation)	3.5-4.0

Acidosis and Rumenocentesis

Sub-acute ruminal acidosis was considered as a causing factor in our herd-wide problem because it is the result of dietary issues and one of its key symptoms is diarrhea. Acidosis has several causes, but each is related directly to the feed and rations. Dr. Limin

Kung, Dairy Science professor at the University of Delaware, provided the following table listing factors that cause acidosis:

Table 2: Common factors leading to acidosis in dairy cattle (Kung)

Diet too high in fermentable carbohydrates
Too high concentrate:forage ratio
Too fast a switch from high forage to high concentrate
Too fast a switch from silage to high levels of green chop forage
Low fiber content in diet
Diet composed of very wet and highly fermented feeds
Too finely chopped forage
Over mixed TMR resulting in excess particle size reduction
Mycotoxins

While analyzing feed rations is a useful tool in diagnosing SARA, it is often difficult to do because of the different variables. As made evident above, the ration is often a leading factor. This can be attributed to the ration developed by the nutritionist, which may contain undesired levels of fermentable carbohydrates. High levels of these carbohydrates result in a high level of lactic acid that the rumen cannot keep up with (Kung). The increased level of lactic acid results in a lowered pH, leading to acidosis. If the ration has the correct levels of fermentable carbohydrates, concentrates, and forages, the cause of acidosis may be attributed to the feeder. While the ration may be within the necessary limits, the feeder is the one ultimately in control of the TMR's accuracy. If the ration is not being properly put into the mixer, all of the work done by the nutritionist is pointless. Proper management of the consistency and accuracy of the feeder falls to the dairy manager and owner. Proper management of feed mixing can best be controlled by utilizing a feed watch system which allows both the feeder and manager to see exactly what is going into the mixer via scales in the mixer that are wirelessly routed to a computer.

Possibly the best test for detecting SARA is rumenocentesis. Rumenocentesis is the collection of ruminal fluid, which is then tested for pH levels. In conducting rumenocentesis testing, a minimum of ten cows should be tested, with less than 30% of them resulting in a pH level <5.50 (Nordlund, 2003). Results showing 30% or more cows with a pH <5.50 indicate a problem of SARA. The process of conducting rumenocentesis, described by Nordlund (2003), involves taking a 4-5” sterile needle and syringe and inserting it into the rumen, typically through the left flank. Prior to insertion, the area should be shaved and sterilized using iodine and alcohol pads. The ideal insertion point is 15 to 20cm behind the last rib (Figure 1). In order to perform a proper testing, a minimum of 3 to 5ml of rumen fluid should be collected. The sample is then placed into a pH-reading device where the results are then recorded and a presence of acidosis is determined.

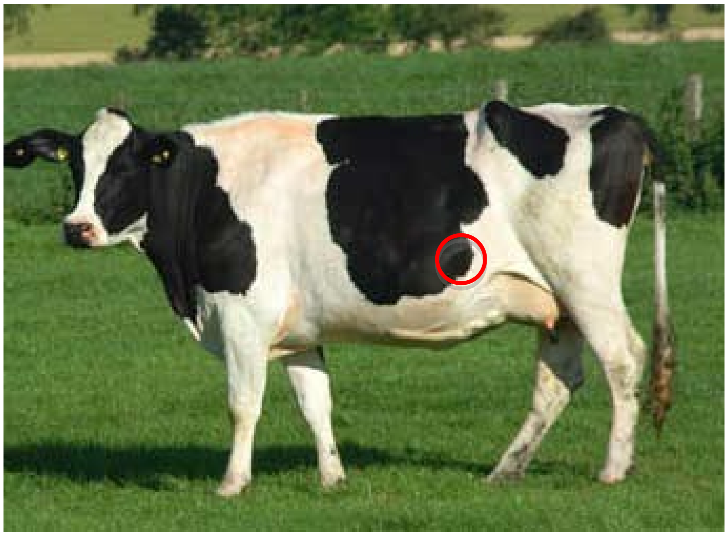

Figure 1: Needle insertion point for rumenocentesis.

Necropsy

A necropsy is a post-mortem examination that is typically used to evaluate internal organs and determine a cause of death. In this case, a necropsy was used to evaluate the organs of the cow to determine a presence of disease or any abnormalities. If a specific disease or abnormality is detected, a necropsy may provide potential treatment or solutions for a herd-wide problem. The ideal timing for conducting a necropsy is immediately after the animal’s death. According to Severidt et al (2002), significant tissue changes can begin to take place as little as 20 minutes post-mortem. These changes tend to occur quicker in cases involving hotter temperatures, as well as cases where the animal had a fever or gastrointestinal abnormalities were involved (Severidt et al, 2002).

Prior to performing a necropsy, the proper form of euthanasia must be used if the animal does not die naturally. The most common forms of euthanasia in dairy cattle, described by Severidt et al (2002), include: gunshot, captive bolt, chemical, and exsanguination. When using the gunshot or captive bolt method, it is recommended to still use some form of chemicals to prevent or limit any limb spasms or respiratory function. Such movements can affect samples being taken. When performing chemical euthanasia, there are two main chemicals that may be used. The first is sodium pentobarbital, which may only be used by a licensed veterinarian. The second chemical that may be used to cause death is Potassium chloride, but requires the animal to be unconscious prior to administering the injection. The final form of euthanasia to be used is exsanguination, or bleeding out. This is done by the cutting of a major artery, but must be done while the animal is unconscious.

Once the animal is euthanized, it should be placed on its left side so that the rumen is on the bottom and allows for the best access to the abdominal organs of the animal. For a detailed checklist and description of the step-by-step process of performing a proper necropsy post-incision, please see the Dairy Cattle Necropsy Manual put together by Colorado State University.

Water Quality

Water can easily be described as the most important nutrient in a cow's diet. Water accounts for 87% of the milk secreted from a cow, making water consumption a high demand for the producing animal. A cow's body weight, at any given time, is comprised of 56-81% water depending on her stage in lactation (Beede, 2006). It is essential that the quality of the water does not prevent total water intake. The cow faces fatal conditions when 20% of her water weight is lost (LeJune et al, 2001). Not only is water needed for milk production, it is also necessary in maintaining body temperature, digestion, and transportation of nutrients throughout the body. Water is an essential factor in nearly every aspect of the cow's body.

Poor water quality can have two direct effects on a dairy herd. One effect results in a reduced water intake by the animals. If the water has an abnormal taste or odor, the cows will not drink it. This odor or taste is attributed to an undesirable component in the water. The second effect caused by poor water quality results in digestive and physiological issues. These effects are caused by anti-quality factors within the water being consumed. Leading anti-quality factors known to result in herd-wide problems include high levels of the following: total dissolved solids (TDS), sulfur, sulfate, iron, manganese, nitrate, and toxic compounds. Toxic compounds causing harmful conditions in water include lead, arsenic, cyanide, and mercury (Beede, 2006).

The sum of all inorganic materials within a sample of water is what determines the TDS. While TDS can often come up with results that are beyond the desired limits, this does not necessarily mean the water quality is bad. The sample may contain high levels of non-harmful organic materials such as calcium. However, TDS levels greater than the desired limit can also have negative symptoms once consumed. Any TDS results showing less than 1,000ppm are considered safe for consumption. Results between 1,000 and 5,000ppm are considered satisfactory, but may sometimes create minor symptoms of diarrhea. Any samples resulting in 5,000-7,000ppm are considered moderately safe, but should not be fed to pregnant animals or young calves. Results between 7,000-10,000ppm are considered unsafe and should be avoided entirely.

Another anti-quality element to consider when dealing with water quality is iron. While mature dairy cattle very rarely experience iron deficiency due to their rations, it is possible for them to consume excess iron. According to Beede (2006), any concentration of iron in water that exceeds 0.3ppm is considered to be a risk in water quality. Excess amounts of iron in water make it less palatable for dairy cows and results in a reduced water intake. One problem with high levels of iron in feedstuffs or water is the decreased ability to absorb copper and zinc. In the cow's intestines the Ferritin System works to control the absorption of iron and prevent toxic levels of iron. Sometime the excess iron bypasses this system and is absorbed anyway. Once this happens, the excess iron results in oxidative stress. Other symptoms of iron toxicity along with oxidative stress include immune system problems, increased mastitis and metritis, increased retained placentas, diarrhea, and decreased feed intake, growth, and milk production (Beede, 2006).

High levels of manganese are another element to be considered, but less is known about it. Manganese is often brought up in the same category as iron and is suggested to cause issues when a presence in water exceeds 0.05ppm. Indicators of high levels of manganese are more known in the actual water source than in the cow. Any black dots on water trough pipes and plumbing may indicate a presence of manganese at undesirable levels (LeJune et al, 2001).

Nitrates are another element toxic to dairy cows at a specific amount. According to Beede (2006), levels of concern are NO_3-N at 20ppm and NO_3 at 88ppm. Nitrates are known to negatively impact reproduction in dairy herds with a special emphasis on conception rates and calving intervals. High levels of nitrates in water are often due to the water source itself. Shifts and changes within the aquifer source of the well can often be attributed to high nitrate levels. Nitrate levels may also be impacted by the depth of the well, time of the year, runoff water, and water that is recycled from irrigation on fields treated with fertilizers (Beede, 2006).

When referring to toxic compounds, heavy metal is another term commonly used. Primary heavy metals and their concern levels that affect water quality include lead (>0.1ppm), arsenic (>0.2ppm), cyanide (>0.1ppm), and mercury (>0.01ppm) (Beede, 2006). Not as much is known about heavy metals and their effect on cattle, but they are a definite concern when dealing with the quality of water being provided.

Water containing abnormally high levels of any of the previously mentioned components may be treated. There are various types of filters that work for different components, as well as treatment methods such as chlorination. Chlorination is a very common treatment method because it has the ability to mask negative tastes or odors as well as dissolve unwanted elements such as iron, manganese and hydrogen sulfide. Chlorination is best coupled with some form of filtration following initial chlorinating. While chlorine is a useful tool in maintaining water quality, over-chlorinating must be prevented. Over-chlorination will result in reduced water intake because of its odor and taste at high levels.

Silage

Silage is a feed that involves taking a forage crop and storing it in a way that results in a fermentation process producing a valuable feed source for animals, especially ruminants. The production of quality silage is a science and takes great attention to detail. The steps in producing such silage begin in the field. Seed selection, harvesting, and piling all play a key role in the process of making silage. In terms of seed selection, Brown midrib (BMR) corn silage is a prime example of hybrids specifically made for silage. While seed selection is important and is something to be highly considered when growing silage; proper harvesting, piling, and ensiling play a more crucial part in a quality product.

There are several different aspects of harvesting that should be focused on when growing forages for silage. According to Schroeder (2004), the main areas of focus during harvesting include the moisture content at time of chopping, the speed at which the crop is harvested, and the length or particle size of the chop. All of these will have an impact on the way the silage is piled and will ultimately affect the fermentation and quality of the product.

When piling silage, the farmer or dairyman must determine the most efficient storage type for their specific situation. This study involves bunker silo-type silage storage, so that is what will be described. It is imperative that proper piling speed and packing practices are utilized. In the packing process, trucks bring in loads of the freshly chopped forage, which is then spread out and piled by a tractor. The tractor continually drives over every inch of the pile in order to pack it as much as possible to reduce the amount of oxygen present throughout. Once the pile is packed properly, it is covered with a plastic sheet, which is then firmly held down by recycled tires to prevent air access to the silage.

Once properly piled and sealed off, the process of fermentation begins. The information in the table below was organized by Schroeder (2004) and adapted from McCullough, Department of Animal Science at the University of Georgia (1975).

Table 3: Six phases of silage fermentation and storage

	Phase I	Phase II	Phase III	Phase IV	Phase V	Phase VI
Age of Silage	0-2 days	2-3 days	3-4 days	4-21 days	21- days	
Activity	Cell respiration; production of CO_2, heat and water	Production of acetic acid and lactic acid ethanol	Lactic acid formation	Lactic acid formation	Material storage	Aerobic decomposition re-exposure to oxygen
Temperature Change*	69-90 F	90-84 F	84 F	84 F	84 F	84 F
pH Change	6.5-6.0	6.0-5.0	5.0-4.0	4.0	4.0	4.0-7.0
Produced		Acetic acid and lactic acid bacteria	Lactic acid bacteria	Lactic acid bacteria		Mold and yeast activity

*Temperature dependent on ambient. Ensiling temperature generally is 15 higher than ambient.

Total Mixed Ration

A TMR is a feeding method in which all hay, grain, silage, and additives are mixed evenly into one ration and then fed. This is a very effective way to feed dairy cows because it minimizes sorting and allows the dairyman to strategically manage nutrients being fed to their herd to maximize milk production and overall cow health. If the herd is properly divided into groups according to production, size, and stage in lactation, different TMRs may be formed to accommodate energy requirements for production and growth (Schroeder, 1997).

Materials and Methods

Medical Treatment

Following the outbreak of loose manure the immediate response was to administer various boluses to aid the cows in combating their digestibility issues. The primary pills used were Laxade™ boluses, Intesti-sorb™ boluses, and charcoal capsules. Each cow in need of medical treatment received a combination of these pills for three to five days at a time. A standard combination of pills used was three Laxade™ boluses and three Intesti-sorb™ boluses. When charcoal pills were in stock they were used with the other two in a ratio of 2:2:2. The laxade boluses that were used each contained 17.9 g Magnesium oxide. These boluses were given to the cows in order to replace the magnesium lost through excess diarrhea, which was unable to be replaced fast enough through the feed ration alone. The Intesti-sorb™ boluses administered contained activated attapulgite, carob flour, pectin, and magnesium trisilicate. The charcoal capsules are used primarily as an absorbent and detoxifier. In addition to these three different pills, capsules of sodium bentonite and copper sulfate were also administered.

Had the outbreak of diarrhea been a random and individual occurrence in the herd, this treatment should have helped in the recovery of these animals. Unfortunately, the symptoms of diarrhea persisted throughout the herd even after treatment. This allowed a clear conclusion that it was not a random sickness in the herd, but rather something bad or toxic that was continually being given to these animals, whether it was a feed issue or water issue. Though it was concluded that the problem was directly related to a feed or water issue, a continued cycle of pills was administered for a four-week period. In the first two weeks, the average number of cows receiving pills each day was between 70 and 80, with a high during week two of 175.

During weeks three and four, the average dropped to between 40 and 50. Even though the number of pills being administered gradually declined, it was not because the herd was improving, but rather because selectivity of cows requiring treatment increased and more efforts were focused in finding a true solution.

Salmonella and BVDV

Samples of manure, blood, feed, and water were taken to test for any indications of salmonella bacteria. When testing for salmonella, 15 fecal samples were taken and sent to the lab. For BVD testing, blood samples were taken from 15 animals and sent to the lab as well. Each sample was sent to Rock River Laboratories and returned negative of any bacteria causing these diseases.

Water Quality

The brief startup of a back-up well induced contaminated water throughout the system. We took samples from the well, holding tank, and water troughs and sent them to the lab for testing. Untouched and sealed test-containers were shipped to us from the lab prior to testing to ensure that there was no outside bacteria or materials getting mixed in with the samples. Once the samples were collected, they were immediately taken to the lab. The tests conducted were looking for any abnormalities in heavy metals, nitrates, and saline levels.

Necropsy

When the initial tests did not come back with any positive results, the next step we took was euthanizing an infected cow to see if we could find any clear problems with the cow's internal organs or blood that could indicate a specific cause. Samples were taken to University of California Davis, where tests and analyses were ran.

Silage

Through the duration of the problem we encountered problems with four different silage piles. Upon realization of a problem with a particular pile, we took samples and had them analyzed in the lab. Meanwhile, we were checking temperatures and dry matter daily. When checking dry matter we used a Koster Crop Tester. We took samples from five different locations throughout the freshly raked face of the pile, mixed them together, weighed out 176g of silage and placed it into a 100g basket. Following initial weigh-in we placed the basket over the burner for 30-45 minutes. We would then re-weigh the sample and calculate the DM. Following the detection of a specific problem in the silage, we re-covered the pile and moved on to the next one.

Almond Hulls

Within the span of two weeks, roughly five loads of almond hulls were delivered to the dairy. Each new load was placed on top of the previous loads, resulting in a first-in-last-out style feeding. Around this same time we received a small amount of rain on the initial bottom pile. The almond hulls on the bottom began to grow molds and turn black. These almond hulls were being fed with the new piles in small dosages for several days. Once made aware of their spoilage, we removed the bad almond hulls from the pile and sent samples of them to the lab in order to be further analyzed.

Feeding and Ration

Following the issues with the silages and almond hulls, we began focusing more and more on the different feeds making up our TMR. We had a sample of our TMR sent to the lab to be analyzed. Meanwhile, we looked into the ration and its nutritional makeup in terms of protein and energy. Furthermore we used the Penn State Shaker Box to test particle size and monitor refusals. In doing this, we noticed that our particle size was a bit too fine. For feeding we use a vertical feed mixer wagon with two augers. In order to adjust particle size we took four of the larger blades in the mixer out and replaced them with smaller ones. Once the blades were adjusted the particle size appeared to meet ideal size. Results of the Penn State Shaker Box test are shown below in Figure 2. Tables 4-7 contain tables that depict our current ration as well as the ration the week following the onset of the problem. Along with each ration is a list of nutrient components.

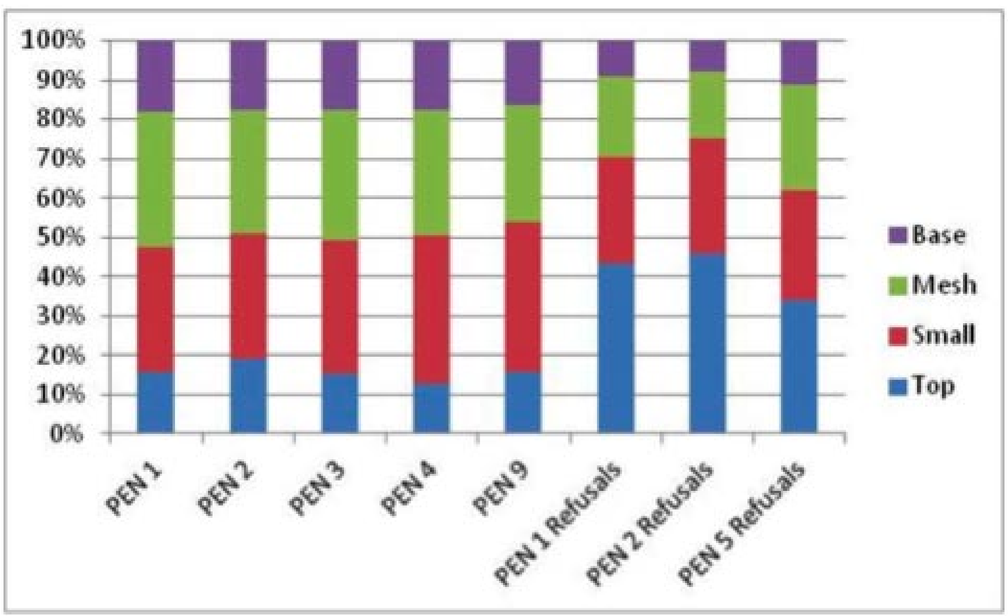

Figure 2: Penn State Shaker Box analysis of TMR rations as fed and refusals.

Table 4: December 22, 2011 High Cow ration based on 1,550lbs body weight, BCS of 3.0, 150 DIM, 84.9lbs milk/day, milk fat of 3.70%, milk protein of 3.10%, inputed DMI of 52.87lbs, and predicted DIM of 53.38lbs

Ingredient	DM (%)	AF (lb/d)	DM (lb/d)	% AF	% DM
Corn	85.00	10.588	9.00	12.32	17.02
Alfalfa	91.62	16.37	15.00	19.04	28.37
Almond Hulls	89.00	7.303	6.50	8.50	12.29
Sorghum Silage	23.30	36.48	8.50	42.44	16.08
EnerGII	98.00	0.51	0.50	0.59	0.95
Corn Gluten	90.00	4.444	4.00	5.17	7.57
Canola	90.00	6.667	6.00	7.76	11.35
Soybean Meal	90.00	2.222	2.00	2.59	3.78
Desperado Mineral Mix (#122811 Western Milling)	99.25	1.3777	1.3673	1.60	2.59
Total		85.9655	52.8673		

Table 5: February 27, 2012 High Cow ration based on 1,500lbs body weight, BCS of 3.0, 0.16lbs/day growth, 120 DIM, 90lbs milk/day, milk fat of 3.75%, milk protein of 3.35%

Ingredient	DM (%)	AF (lb/d)	DM (lb/d)	% AF	%DM
Alfalfa	90.00	6.00	5.40	6.70	10.69
Wheat Silage	31.00	20.00	6.20	22.33	12.27
Corn Silage	30.00	30.00	9.00	33.50	17.81
Almond Hulls	87.00	4.00	3.48	4.47	6.89
Rolled Corn	86.00	10.50	9.03	11.73	17.87
Cottonseed	90.10	3.00	2.70	3.35	5.35
Soybean Meal	90.00	3.00	2.70	3.35	5.34
Wheat Millrun	95.00	3.50	3.32	3.91	6.58
Canola Meal	90.17	3.00	2.71	3.35	5.35
DDG	90.00	5.00	4.50	5.58	8.91
Mineral Mix	94.95	1.00	0.95	1.12	1.88
Megalac	97.00	0.30	0.29	0.34	0.58
Sodium Bicarbonate	99.50	0.25	0.25	0.28	0.49
Total		89.55	50.53		

Table 6: Macro Nutrients for December 22, 2011 ration

Nutrient	DM	AF
Dry Matter (%)	100.00	61.50
Forage (%)	44.45	27.34
CP (%)	17.87	10.99
RUP (%CP)	43.62	26.83
RDP (%CP)	56.38	34.67
RDP (%DM)	10.07	6.20
Sol Protein (%CP)	30.22	18.58
ME (mCal/lb)	1.04	0.64
NEl (mCal/lb)	0.67	0.41
Nem (mCal/lb)	0.64	0.40
NEg (mCal/lb)	0.38	0.23
ADF (%)	22.72	13.97
NDF (%)	32.18	19.79
Forage NDF (%NDF)	59.36	36.51
Forage NDF (%)	19.10	11.75
peNDF (%)	23.84	14.66
Lignin (%NDF)	12.36	7.60
Lignin (%DM)	4.56	2.81
NFC (%)	36.85	22.66
Silage Acids (%)	0.19	0.12
Sugar (%)	7.08	4.36
Starch (%)	15.46	9.51
Sol Fiber (%)	13.63	8.39
EE Total (%)	3.39	2.08
LCFA Total (%)	2.61	1.61
Ash (%)	10.06	6.19

Table 7: Macro Nutrients for February 27, 2012 ration

Nutrient	DM	AF
Dry Matter (%)	100.00	56.43
Forage (%)	40.77	28.36
CP (%)	17.49	9.87
RUP (%CP)	37.64	37.64
RDP (%CP)	62.36	62.36
RDP (%)	10.91	6.15
Sol Protein (%CP)	31.39	31.39
ME (mCal/lb)	1.22	0.69
NEl (mCal/lb)	0.78	0.44
Nem (mCal/lb)	0.78	0.44
NEg (mCal/lb)	0.52	0.29
ADF (%)	21.17	11.95
NDF (%)	31/32	17.68
ForageNDF (%NDF)	57.23	32.29
Forage NDF (%)	17.93	10.12
peNDF (%)	15.76	8.89
Lignin (%)	4.13	2.33
NFC (%)	39.66	22.38
Silage Acids (%)	1.57	0.88
Sugar (%)	5.69	3.21
Starch (%)	24.33	13.73
Sol Fiber (%)	8.08	4.56
EE Total (%)	5.36	3.03
LCFA Total (%)	4.48	2.53
Ash (%)	8.55	4.82

Results and Discussion

Veterinarian Assessment

The first tests performed following the outbreak involved various infectious diseases that may be affecting the herd and are known to cause widespread diarrhea and decreased milk production. The potential diseases taken into account were Salmonella, Bovine Viral Diarrhea Virus (BVD), Winter Dysentery, and Corona Virus. Though they were considered, Corona Virus and Winter Dysentery were immediately ruled out. These diseases both cause diarrhea in cattle but their symptoms differed from what we were seeing in the herd. Fecal and water samples were collected and diagnosed by our veterinarian to determine whether or not the issue was related to Salmonella or BVD.

Following the results from these tests, a sick cow bearing all of the symptoms seen throughout the herd was euthanized and a field necropsy performed to further analyze possible causes. The necropsy was done on December 28th by two veterinarians from University of California Davis, and paid special attention to the rumen, intestines, bowels, colon, kidneys, liver, and blood. After testing was complete and results analyzed, no significant abnormalities were detected. The test revealed a widespread inflammation of the small bowel and colon. There was no evidence of infectious disease affecting the animal, nor of heavy metal poisoning. Mild changes were noted in the heart muscle and kidneys, but these were thought to be unrelated to the bowel inflammation and were likely to be incidental.

On December 29th the UC Davis veterinarians returned to walk through the dairy and perform body condition scoring (BCS) tests, fecal scoring, and rumenocentesis testing. The BCS was conducted by scoring 400 cows across the dairy at all different levels of production. Only one veterinarian was used to assure there was no bias in scores assigned. The purpose of BCS testing was to determine the direct impact the outbreak of diarrhea was having on the condition of the animals. The results of the BCS are shown in Figure 4. The fecal scoring performed was intended to determine fecal consistency throughout the herd on a 1-5 scale, 1 being very loose and 5 being very dry. The results of the fecal scoring are shown in Figure 3. The final test of the day was rumenocentesis. This test was used to measure the pH of ruminal fluid to determine whether or not the herd was experiencing acidosis. The ruminal fluid was extracted with a syringe and needle through the left flank of the animal roughly six hours after feeding. Acidosis typically results when rumen pH is less than 5.5. A herd-wide problem of SARA is present when greater than 25% of samples collected have a pH less than 5.5. Results are presented in Table 8. The information found in Table 8 and Figures 2-4 are credited to Dr. Hugh Crockford and Dr. Alistair Kenyon of UC Davis.

Table 8*:* Rumen pH values from 9 cows taken by percutaneous left flank rumenocentesis 6 hours post delivery of TMR feed. *****pH as measured cowside by Cardy Twin meter (calibrated as per manufacturers recommendations before and after measurements taken)

Cow ID #	**pH***
947	6.6
1989	6.0
1722	6.2
1459	6.0
87	6.6
2085	5.7
2282	6.1
2074	6.2
2138	6.0
Average pH	6.15

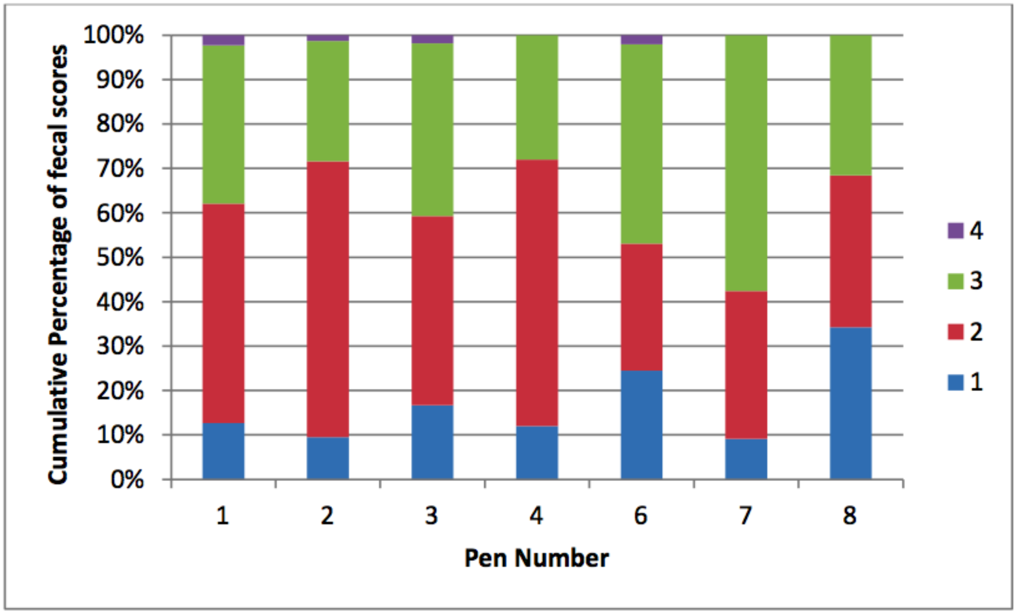

Figure 3: Fecal scores by pen (n=420; where 1=liquid "pea-soup" diarrhea and 5= horse manure-like).

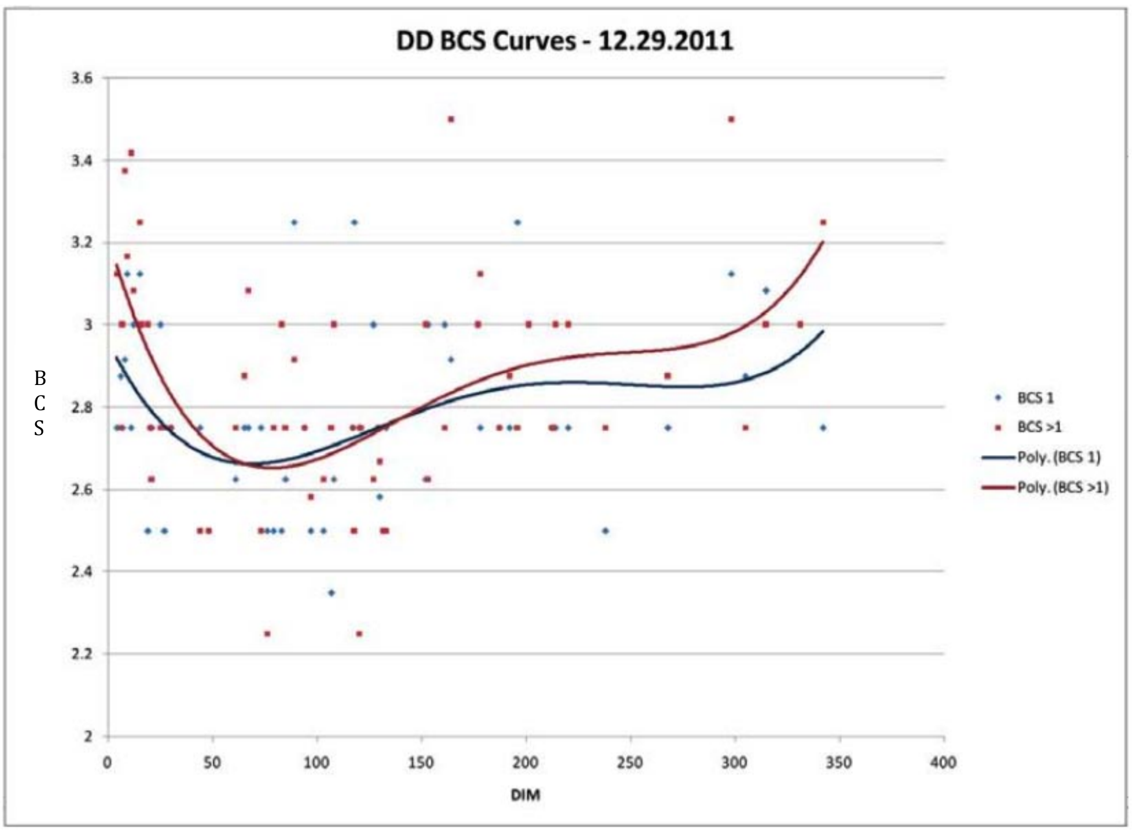

Figure 4: Body condition scores by days in milk.

Salmonella and BVDV

At the onset of the problem it was recommended to look into diarrhea causing diseases such as salmonella and bovine viral diarrhea virus (BVDV). Each of these contagious diseases in dairy cattle result in the symptoms we were seeing throughout the herd. The biggest and most obvious symptom was the massive diarrhea outbreak. Secondary symptoms included lowered BCS and increased abortions. The number of abortions encountered during December and January was higher than usual at 18 per month. Generally, diseases like salmonella and BVD, though contagious, will only be present in a few animals throughout the herd. It is highly unlikely that an outbreak of either disease would occur in the 80 percent of the herd within a week like we were witnessing. Regardless, we took samples and performed analyses to determine whether or not our animals were infected with salmonella or BVDV. All samples that returned from the lab were negative for salmonella and BVD, as well as neospora, IBR, PI3, and Leptospirosis.

Water Quality

Our next suspect in the cause of this outbreak was our water. Leading up to the onset of the problem we had been in contact with the former manager of the dairy for the previous family who had lived there. He informed us that they used to treat the well two times a year. He further explained the when the well went untreated the dairy experienced higher incidences of health issues in the herd. The health issues he listed included decreased intake of feed, mastitis, and general overall health. Upon hearing this we proceeded to treat the well with twenty gallons of chlorine and added a mechanical chlorinator to the inlet of the supply tank. The level of chlorine was possibly too high and there was a slight scent of chlorine in the water troughs. The data in Table 9 shows the levels of various components within the water following chlorine treatment.

On December 7th the backup well on the dairy was started, which introduced a rust-colored water into the vertical holding tank. This water proceeded through the system ending up in the water troughs. The amount of contaminated water that made its way into the cows' water supply probably accounted for about 1/15 of the days supply. Regardless of the amount, this bad water and the excess amount of chlorine were both thought to have an impact on the outbreak. As soon as the outbreak occurred the chlorinator was immediately turned off and water was sent to Rock River Laboratories to be tested.

Table 9: Livestock Water Analysis Report

Component	Result	Expected	Possible Problems for Mature Cattle
Total Coliform/100ml	**<1**	<1	15
e. Coli	**Negative**		
Nitrates, ppm	**52**	0 – 44	100
Nitrates – Nitrogen, ppm	**12**	0 – 10	23
Sulfates, ppm	**103**	0 – 250	1,000
Sulfates – Sulfur, ppm	**34**	0 – 83	333
Chlorides, ppm	**63**	0 – 250	300
Hardness, ppm $CaCO_3$	**148**	0 – 370	
Total Dissolved Solids (TDS), ppm	**416**	0 – 500	3,000
Calcium (Ca), ppm	**56.9**	0 – 100	500
Phosphorous (P), ppm	**<0.1**	0 – 0.3	0.7
Magnesium (Mg), ppm	**1.5**	0 – 29	125
Potassium (K), ppm	**3.2**	0 – 20	20
Sodium (Na), ppm	**60.6**	0 – 100	300
Iron (Fe), ppm	**<0.01**	0 – 0.3	0.3 (taste)
Zinc (Zn), ppm	**<0.01**	0 – 5	25
Copper (Cu), ppm	**<0.01**	0 – 0.6	0.6
Manganese (Mn), ppm	**<0.01**	0 – 0.05	0.05 (taste)
Molybdemum (Mo), ppm	**<0.01**	0 – 0.07	0.07
pH	**7.9**	6.8 – 7.5	<5.5 or >8.5

Almond Hulls

At the same time as the water issue we noticed a problem with our almond hulls. It had rained half an inch on November 20th and the water formed a puddle around the base of the almond hulls. This almond hull pile was fed and dwindled down, but new loads of almond hulls were delivered on top of the remainder of the wet feed. This produced a first-in-last-out style feeding. The small amount of wet almond hulls was stuck at the bottom of the pile and was given the opportunity to form molds. About five truckloads of new feed were delivered and fed before we noticed the now black almond hulls at the bottom of the pile. We do not know the amount of bad almond hulls fed at a time or the frequency, but we still saw this as a potential cause. The bad almond hulls were removed from the pile immediately and a sample taken and sent to the lab to be analyzed. The sample returned from Rock River Laboratories with the following results:

Moisture: 16.64%
Dry Matter: 83.36%
Fumonisin: 0.3 ppm on a DM basis
Vomitoxin: 1.1 ppm
Aflatoxin: 25.9 ppb
Zearalenone: 193.3 ppb

When reviewing these results, the numbers that raised a red flag were the ones associated with Aflatoxin and Zearalenone levels. Both of these toxins are very powerful and potentially cause issues in the form of liver damage, pneumonia-like symptoms, and abortions. While we did see toxic levels of Zearlenone and Aflatoxin, we did not see this as a certain cause to the problem that lasted a span of eleven weeks while this was only fed in spall portions for several days.

Silages

Even though the exposure to toxic water and almond hulls was thought to have had an impact, the primary suspicion causing the diarrhea outbreak was forage quality. The initial assumption was that there was a toxic level of mycotoxins in one of the silage piles. During fall of 2011, the dairy harvested and ensiled four different silage piles. Two of the piles were corn silage and two were sorghum silage. Of the four separate piles, problems were encountered in each. The first silage to be fed to the herd was one of the corn silage piles (north pile). The issues involved with this pile were that it was packed and covered too dry and had a heavy population of pigweed. The second and third piles opened were the two sorghum silage piles, which both had similar issues involving poor fermentation. Lastly, the other corn silage pile (south pile) was opened, which had corn from two separate fields and was improperly packed. Dealing with each of these issues, the importance of silage quality as well as pre and post harvest procedures was made quite clear. Listed in Table 10 on the next page are the results from both corn and sorghum silage testing.

The northern corn silage pile had low moisture content at ensiling as well as a known presence of pigweed. At harvesting, the corn was direct-cut and piled immediately. In a study determining forage moisture content, Gay et al. (2009) report that ensiling silage with low moisture may result in incomplete fermentation. Furthermore, they recommend that direct-cut silage be ensiled at 70 to 85 percent moisture. The north pile was analyzed in a laboratory and the results showed moisture content of 62.60% and a dry matter of 37.40%. When silages are ensiled at low moisture levels, not only do they often have incomplete fermentation, they also become more susceptible to heat damage (Coblentz and Hoffman, 2008).

Table 10: Corn and sorghum silage results paired with their ideal ranges

Comonent	Unit	Corn Silage	Corn Silage Ranges	Sorghum Silage	Sorghum Silage Ranges
Moisture	%	57.99	60-70	74.37	65-70
Crude Protein	%	6.79	6-9	7.69	6-8
Soluble Protein	%	54.64	45-70	42.52	30-55
ADF	%	21.53	25-30	40.29	30-45
NDF	%	42.33	35-48	60.14	45-65
Starch	%	36.83	10-35	13.13	10-15
Fat	%	2.02	1-4	3.14	1-4
Calcium	%	0.25	0.15-0.45	0.5	0.3-0.5
Phosphorus	%	0.18	0.25-0.4	0.27	0.2-0.35
Magnesium	%	0.11	0.15-0.25	0.25	0.25-0.35
Potassium	%	0.74	1.1-2.5	2.49	1.8-3
Sulfur	%	0.08	0.1-0.15	0.14	0.1-0.25
Sodium	%	0.04	0.01-0.05	0.16	0.01-0.05
Chloride	%	0.16	0.3-0.9	0.58	0.3-0.8
pH		4.26	4.5-5.5	4.3	4.5-5.5
Ash	%	4.42	5-7	13.98	8-15
Lactic Acid	%	3.5	3-7	1.22	3-7
Acetic Acid	%	3.67	1-3.5	1.64	1-3.5
NFC	(calc)	45.12	35-45	16.36	10-25
NEL	(calc)	0.657	0.55-0.8	0.533	0.55-0.7

Aside from the northern pile being dry, which made it susceptible to heat damage and pseudo-fermentation, it was also infested with redroot pigweed in a large portion. According to Zadnik et al. (2008), redroot pigweed is a common weed that is toxic because of its thick stems, which are able to absorb large amounts of nitrates. This makes pigweed grown on farmland fertilized with manure potentially more toxic due to the abundant supply of nitrates the manure provides to the soil. Once consumed by the cow, nitrate is broken down into ammonia within the rumen (Robinson, 2010). The ammonia is then used by the microorganisms in the rumen as a source of N, allowing them to grow and thrive. When there is an abundance of nitrate in the diet, the rumen cannot fully break it down into ammonia. The partial breakdown of nitrate forms nitrite, a toxic compound that lessens the cow’s ability to digest fibers. Robinson (2010) says that cellulolytic bacteria, which break down fiber in the rumen, cannot handle this compound and will result in lowered milk production and feed intake. He goes on to explain that when there is an excess amount of nitrite in the rumen that cannot be digested, it is absorbed into the bloodstream where it interacts with hemoglobin and takes the place of oxygen. This interaction produces methemoglobin. Methemoglobin cannot carry as much oxygen in the blood as hemoglobin, which results in less oxygen being carried throughout the cow's body. High levels of nitrite in the rumen can eventually lead to the death of the animal, but sub-acute symptoms that occur may include: lowered milk production, reduced feed intake, increased abortions and reproductive failure, faster breathing and heart rates, and diarrhea.

Once a poor reaction to the corn silage was observed in the herd, a quick change was made to the two sorghum silage piles. Both of these piles were a BMR 108 sorghum crop and had very similar results. The fermentation numbers on the acetic and lactic acid, and the balance between the two, show that little to no fermentation took place when ensiled. In a study done by Schroeder (2004) describing silage fermentation, he states that acetic and lactic acids develop between days two and 21. During the first phase, which lasts typically only two days, CO_2 is produced. After the production of CO_2, acetic and lactic acids are produced. When each of the two sorghum silage piles were ensiled, they had a higher moisture content which resulted in less oxygen throughout the pile. Less oxygen results in a lower production of CO_2 and slower fermentation. Due to the minimal fermentation, once the pile was uncovered for feeding and subject to oxygen, it began to heat up to temperatures over 100°F. This temperature increase, accompanied with oxygen contact, sparked what was believed to be a secondary fermentation.

Not only were the fermentation and moisture levels out of acceptable range, there was an ash content twice the desired amount. Ash percentage in silage should be no more than 7-8%.

Each of the two sorghum piles had an ash content of 14-15%. The high ash level was a direct result of poor chopping practices. A mower was used to harvest rather than direct-chop, leaving the sorghum lying in the field to be picked up at a later time. When it came time to pick up, the sorghum was sucked up as well as a lot of dirt and excess manure in the fields, increasing the ash content. To make matters worse, one of the fields the sorghum was grown on was treated with 25 tons of manure that was not properly disked into the soil. This could have potentially added to the high ash levels and too much nitrate. In response to the fermentation and ash issues, the sorghum silage piles were re-covered.

The final pile used was the last corn silage pile. This pile had two specific issues. The first and most prominent issue was that it was very poorly packed. During the packing process, this corn silage pile had an average of twenty truckloads coming in each hour. Due to the weight and speed of the tractor, the number of loads per hour should have been reduced to 10-12 for ideal packing and density. The result of the pile being too loosely packed was an excess amount of oxygen, allowing for more mold and mycotoxin growth as well as fermentation issues. Not only was the pile poorly packed, it also contained corn of unequal quality from two separate farms. When opened up for feeding, six to eight feet of hot and moldy silage was removed from the top layer, resulting in a large amount of wasted feed. Fortunately, the lower half of the silage was tested to have good quality and had positive effects on the herd.

Total Mixed Ration

The TMR was a crucial aspect of the problem on our dairy. Whether it was the cause or not, it was still a helpful tool in getting the cows back to where they had been in terms of health and production. Through the duration of the herd-wide problem, the ration was changed many times in hopes of firming up the loose manure and gaining back milk production. Samples of TMR fed to the milk cows were taken for shaker box analysis and showed a consistency both within and between feed loads. Top tray proportions were slightly higher than Penn State guidelines, however, this is not unusual for diets containing almond hulls. The level of sorting resulted in inconsistent nutrient and feed intake. This may have been a contributing factor to the protein and energy balance issue as well as making bunk management harder to maintain. The continued problems within the cows' stomachs caused inconsistent consumption, which resulted in constant ration size changes.

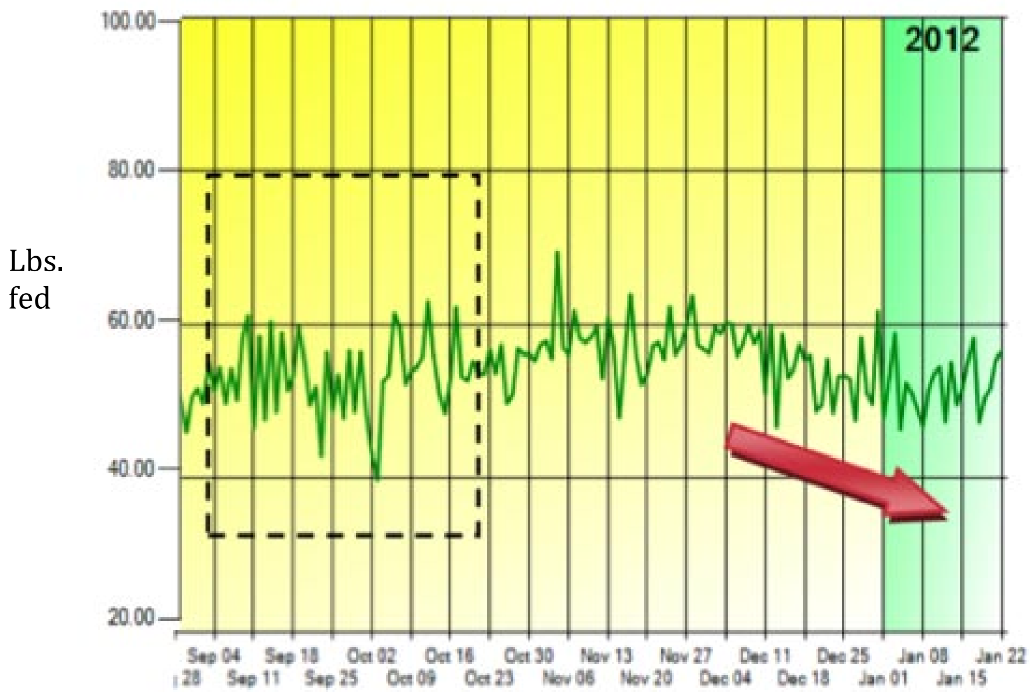

Figure 5: Feed ration size adjustments from September to January due to varying intake levels.

The level of refusals can be attributed to several various causes. One cause of sorting would be the result of an odor or taste not desired by the cow. This would most likely be a response to silage or hay quality. Given the vast number of problems encountered with our silages, it is realistic to think that this may have been a cause. Secondary causes to the sorting may have been in response to the state of the cows' gut comfort. Since the cows were already having digestive issues, they may have been sorting accordingly to pick out the feeds that taste and feel best while being digested. Regardless of the cause, sorting has a negative impact on the nutritional makeup of the feed being consumed by the cows. Sorting causes inconsistencies in nutrient intake and makes it more difficult to form and feed proper rations.

In response to the level of refusals, we adjusted the blades in our feed wagon to get the ideal particle size. Through the different silage changes we constantly saw a change in the amount of refusals. Once we began feeding our winter forage that we knew was good quality, sorting was greatly reduced. By making these two changes, sorting ceased and refusals were minimal.

Protein and Energy Balance

In the initial ration we expected that there was a very high concentration of protein, particularly soluble protein. Because of this, the cows were expending larger amounts of energy to excrete the excess nitrogen present from the protein. The negative energy balance resulting from the high soluble protein and the low energy in the diet had a huge impact on the state of the rumen and the consistency of the manure. Due to the lack of energy in the form of starch, the rumen bacteria could not grow and produce enough digestive organisms to break down the feed (Davidson et al, 2003). With the TMR not being fully digested, less nutrients and carbohydrates were broken down and absorbed. This resulted in a domino effect of three things, 1) a lack of digestion due to low rumen population, causing inconsistent manure and feed intakes, 2) excess nitrogen, requiring excess energy to excrete it, and 3) a lack of energy to maintain milk production due to the ration and low intake.

Conclusion

In conclusion, this study evaluated the potential causes of a herd-wide outbreak of diarrhea and an average reduced milk production of fifteen pounds. While our investigations failed to pinpoint a particular incident leading up to this event, this study was not a total failure. The problem persisted for a total of 77 days, a time in which we were constantly learning new things. In searching for a solution we were taught in depth lessons in the areas of nutrition, silage production, and water quality. Specific things learned include the balance of energy and protein within a ration, proper harvesting and ensiling techniques to ensure a quality silage, and proper treatment of water as well as essential benchmarks to meet. Though a solution to this specific event remains elusive, the herd has returned to normal health and full production. Meanwhile, the various causes we looked into have educated us for potential problems we may encounter in the future.

REFERENCES

Beede, D. K., 2006. Evaluation of Water Quality and Nutrition for Dairy Cattle. High Plains Dairy Conference, Amarillo, TX.

Coblentz, W. and Hoffman, P. 2008. Heat Damaged Forages: Effects on Forage Quality.

Davidson, S. S., Brownie, C. C., Fellner, V. V., Whitlow, L. W., Hopkins, B. A., Diaz, D. E., and Bolt, S. M. 2003. Effects of amounts and degradability of dietary protein on lactation, nitrogen utilization, and excretion in early lactation holstein cows. Journal Of Dairy Science, 86(5), 1681-1689. NAL Call Number. 44.8 J822

Gay, S. W., Grisso, R., Smith, R. 2009. Determining Forage Moisture Concentration. 442-106.

Grein, M. F. 1995. Bovine viral diarrhea in a dairy herd. Canadian Veterinary Journal-La Revue Vétérinaire Canadienne, 36(3), 184-185.

Kellogg, W. Body Condition Scoring With Dairy Cattle. University of Arkansas, Agriculture and Natural Resources. FSA4008.

Kung, L. Acidosis in Dairy Cattle. Ruminant Nutrition & Microbiology Laboratory, University of Delaware.

LeJeune, J. T., Rice, D. H., Hancock, D. D., Besser, T. E., and Merrill, N. L. 2001. Livestock drinking water microbiology and the factors influencing the quality of drinking water offered to cattle. Journal Of Dairy Science, 84(8), 1856-1862.

McGuirk, S. and Peek, S. 2003. Salmonellosis in Cattle: A Review. Proceedings of the 36th Annual Conference of American Association of Bovine, Sept. 15-17, Columbus, OH.

Navarre, C.B. 2006. Bovine Viral Diarrhea Virus (BVD) of Cattle.

Nordlund, K., 2003. Herd-based diagnosis of subacute ruminal acidosis. Proceedings of the 36th Annual Conference of American Association of Bovine, Sept. 15-17, Columbus, OH., pp: 1-6.

Robinson, P. H. 2010. Nitrates and Dairy Cattle: Cause for Concern?

Schroeder, J. W. 1997. Using a Total Mixed Ration for Dairy Cows. AS-769.

Schroeder, J. W. 2004. Silage Fermentation and Preservation. AS-1254.

Schroeder, J. W. 2004. Corn Silage Management. AS-1253.

Severidt, J. A., Madden, D. J., Mason, G., Garry, F., and Gould, D. 2002. Dairy Cattle Necropsy Manual. Colorado State University, Integrated Livestock Management.

Shaver, R. D. 2007. Supplementation of High Corn Silage Diets for Dairy Cows

Witte, C. 2003. The Presence, Effect, and Diagnosis of Zearalenone in Dairy Cattle.

Zadnik, T., Staric, J., Klinkon, M., Cigler, T., and Jezek, J. 2008. Poisoning Associated with Ingestion of Redroot Pigweed (Amaranthus retroflexus) in Cattle – Case Report. The Open Veterinary Science Journal, 2008, 2, 127-129.