BOVINE NUTRITIONAL NEEDS

Student Author

Shirley Nigaglioni is a junior in the School of Agriculture majoring in animal sciences (concentration: preveterinary medicine). Nigaglioni's research began as a requirement for her Food, Environmental, Engineering, and Life Sciences (FEELS) grant in fall 2010. Her research on digestibility when feeding dry or ensiled forages to young dairy heifers involves working in the field and in the lab analyzing data. Nigaglioni is active in the Puerto Rican Student Association board, is a member of the National Society of Leadership and Success, and is a participant in the Leadership Certificate Program. After graduation, Nigaglioni plans to attend veterinary school, focusing on small, avian, and exotic animals.

Mentor

Tamilee Nennich earned her B.S. degree from the University of Minnesota, Crookston in 1999, M.S. degree from the University of Minnesota in 2001, and Ph.D. from Washington State University in 2004. Nennich joined the Department of Animal Sciences at Purdue University as an assistant professor and Extension Dairy Specialist in the area of nutrition and nutrient management in October 2007. The goal of her research program is to evaluate management strategies that increase the utilization of nutrients and reduce the amount of nutrients imported to the farm while maintaining or improving animal health and performance.

Abstract

The diets fed to growing animals are very important to ensure that young animals have the proper nutrients available for growth. When feeding dairy heifers, a farmer's goal is to feed a very digestible diet that will provide nutrients to keep dairy heifers healthy and allow them to grow faster, while spending less money on feed. The objective of this study was to determine whether feeding heifers diets containing dry or ensiled forage (haylage) improved digestibility. Our hypothesis was that incorporating hay into the diet of 16-week-old dairy heifers would provide a more digestible source of nutrients. For this study, 12 heifers were randomly assigned to treatments, with 6 heifers fed hay-based diets and the other 6 heifers fed haylage-based diets. The heifers were housed in individual pens and fed individually on a daily basis for 8 days. Fecal samples were collected during the last 3 days of the feeding period. The fecal collection was achieved by collecting fecal samples from individual heifers every 6 hours over a 3-day period. Digestibility of the diets and nutrients were determined using chromic oxide as an external marker. In order to determine the digestibility of haylage or hay diets fed to the heifers, the percent of chromic oxide in feed was compared to the percent of chromic oxide in feces. The neutral detergent fiber (NDF) of the feeds and feces was determined using the Ankom Fiber Analysis System. Data were analyzed using the Proc Mixed procedure of the Statistical Analysis System. The dry matter digestibility of the diets were similar between treatments ($P = 0.19$) and was 68.4% for the hay diet and 66.6% for the haylage diet. The NDF digestibility was also similar between diets ($P = 0.21$) with an NDF digestibility of 68.4% for hay and 66.1% for haylage diets. In summary, feeding dairy heifers hay-based diets did not significantly improve either the dry matter or NDF digestibility of the diets.

Nigaglioni, S. (2012). Bovine nutritional needs: Digestibility of dry and ensiled forages when feeding young dairy heifers, *Journal of Purdue Undergraduate Research*, 2, 48–53. doi:10.5703/jpur.02.1.08

Keywords

chromic oxide, digestibility, hay, haylage, heifer

BOVINE NUTRITIONAL NEEDS:

Digestibility of Dry and Ensiled Forages When Feeding Young Dairy Heifers

Shirley Nigaglioni, Animal Sciences

INTRODUCTION

Feed costs for lactating dairy cows often account for more than half of all the costs associated with producing milk (Stallings, 2011). For this reason, lowering the feed costs while still providing a balanced diet helps dairy cattle producers succeed economically. Similarly, feed is one of the main costs when raising dairy heifers (Figure 1). Dairy heifer feeding and management account for nearly 20% of production costs for dairy producers, and dairy heifers do not provide a return on investment until they begin producing milk (Lormore, 2005). Economic research has recognized that the period from birth until weaning is when the highest daily expense is incurred during dairy heifer development due to high labor and milk feeding costs (Hopkins & Whitlow, 2007). Assuring that animals are fed adequate nutrients for maintenance and growth is one of the most important aspects of raising dairy heifers.

Harvesting forage at its optimal stage of maturity and using it as feed for dairy cattle year-round is desirable because this forage can be used to supply animals with a high-quality and palatable feed throughout the year. As the growth, maturity, and quality of forage changes, there is a need to harvest and store it in order to have high-quality feed available throughout the year. There are certain advantages to storing forages, including less field losses when forages are mechanically harvested compared to grazing (Schroeder, 2004), preservation of more nutrients when they are harvested at the proper times, and consistent quality when gathered at optimal maturity.

Hay, commonly used as animal feed for livestock such as cattle, horses, goats, and sheep, is forage that has been cut, dried, and stored. Storing forages as hay is the most commonly used method for storing them.

Although drying forages into hay is common, almost any legume or grass can also be harvested wet and ensiled. Ensiled forages are often referred to as haylage. One of the main advantages of ensiling forages is the reduction of drying time in the field, allowing the harvesting process to be completed more quickly. This is especially important in climates with moderate to high rainfall and in areas where humid weather will slow drying times for hay. Ensiling is

Figure 1. Dairy heifer used in the study.

a fermentation process. In order for ensiling to properly occur, a quick drop of pH is necessary. A quick pH drop keeps losses of nutrients to a minimum and preserves the quality of the forage. During the ensiling process, lactic acid bacteria digest freely available carbohydrates in an environment with no oxygen. This process lowers the pH quickly and ensures that enzymatic reactions and other energy losses are prevented. The ensiled forage will continue to need to be stored using anaerobic methods. The bales in this study were wrapped in plastic to maintain an anaerobic environment.

Different ages and production levels of dairy cattle require different feeding strategies. Calves are fed milk until they are weaned, and during the milk-feeding period calves also start eating grain. Several weeks after weaning, forages are introduced into the diets of heifers. The amount of forage fed to dairy animals gradually increases and will continue to comprise at least half of their diet even when they are lactating cows.

For many years, dry hay has been used in the dairy industry as a main feed source for dairy heifers. However, ensiled forages are often used as a substitute for hay in dairy heifer diets. Due to their digestive physiology, and especially the presence of a rumen, dairy cows and heifers are able to digest and utilize feeds like hay and ensiled forages that contain large proportions of fiber. As the ensiling process allows producers to preserve forages that contain more moisture than what is used for making hay, ensiled forages give producers

flexibility when harvesting feed and can also reduce costs associated with labor and equipment. At this time, there have previously not been any specific studies comparing hay to haylage in dairy heifer diets, though other studies have compared feeding hay and silages to lactating dairy cattle (Brundage & Sweetman, 1963). In the industry, hay and haylage have been used interchangeably in dairy heifer diets as the feeds often have the same nutritive value. However, little is known about how dairy heifers are able to utilize forages stored as haylage compared to hay. Determining the digestibility of hay and haylage-based diets provides information to dairy farmers about which feed is a better option for feeding dairy heifers. More digestible diets help animals to utilize feed more efficiently, and in turn, require less feed to reach a desired growth rate. More specifically, more digestible feeds are better options for heifer raisers because they allow the heifers to obtain more nutrients from the same amount of feed, potentially allowing the animal to grow more quickly and enter lactation at an earlier age. Diet digestibility can be determined using chromic oxide techniques in short-term digestion trials (McGuire, Bradley, & Little, 1966; Hardison, Linkous, Engel, & Graf, 1959). Chromic oxide is not readily absorbed by the animal, so the concentration of chromic oxide in the feed will be proportional to the concentration in the feces. The use of chromic oxide measurement provided a means of determining whether hay or haylage was a more digestible feed for dairy heifers.

HYPOTHESIS

Our hypothesis was that incorporating dry hay in the diet of 16-week-old dairy heifers would provide a more digestible source of nutrients than haylage.

OBJECTIVE

The objective of this study was to determine whether feeding diets containing dry or ensiled forage to dairy heifers improved feed digestibility, which could result in more efficient growth of dairy heifers.

MATERIALS AND METHODS

Sample Collection and Analysis

Twelve Holstein heifers were housed in experimental pens (under roof). They had a space of 6.25 m² per heifer. Heifers used in this study were approximately 16 weeks old and were housed in individual pens (Figures 2 and 3). Heifers were randomly selected from group pens and assigned to 1 of 2 treatments in a completely randomized design. The dietary treatments were 40% hay or 40%

Figure 2. Dairy heifers walking to their pens.

haylage (ensiled forage) on a dry matter basis. Each heifer received a complete diet containing 40% dry hay or haylage, 36% corn, and 24% protein pellet (on a dry matter basis). The protein pellet contained 0.37% chromic oxide in order to calculate diet and fiber digestibility. Prior to the start of the digestion study, individual heifers had been fed their respective treatment diets for a month to allow time for the heifers to adapt to the diets. The total duration of the trial was 8 days. Samples (300 to 400 g) were collected daily from each diet. The first five days on the diet were intended to allow the heifers to adapt to individual housing and the feed containing the chromic oxide. Beginning on the sixth day and continuing for the last three days of the trial, fecal samples (200 g) were collected from individual heifers every 6 hours, resulting in a fecal sample from each heifer being collected from every 2-hour period during a day in an effort to capture any diurnal variation that may have occurred.

Diet samples were dried at 60°C for 48 hours in a forced-air oven and fecal samples were freeze-dried. All samples were ground through a 1 mm screen using a Wiley Mill (diet samples) or a cyclone mill (fecal samples). Approximately 0.5 g of dried diet or fecal samples were weighed for chromic oxide analysis or neutral detergent fiber (NDF) analysis. NDF is the proportion of the plant cell wall that represents cellulose, hemicellulose, and lignin.

The amount of hay and haylage fed to heifers and the percentage of chromic oxide in feed were compared to the percentage of chromic oxide in feces. Digestibility was calculated on the basis of this comparison.

The equipment used to do this research was an atomic absorption spectroscope (AAS), which was used to determine percent of chromic oxide in the feed and feces. An Ankom Fiber Analyzer was used to determine the NDF in the feeds, which is the most common measure of fiber used for animal feed analysis. All samples were analyzed in duplicate, and standard samples were analyzed at the same time to assure that the analysis was accurate. Data were analyzed by using a statistical program called Statistical Analysis System (SAS). This program compared the data to determine if there was a statistical difference between treatment effects. Data were analyzed using the MIXED procedure of SAS 9.2 (SAS Inst. Inc.) with heifer as the experimental unit. Statistical models included treatment as a fixed effect and heifer within treatment as a random effect. Least-squares means are presented in the results.

Weight Tracking

Heifers were moved in a group to the chute and scale handling facilities. Heifers were weighed using an electronic scale with a Tru-Test XR3000 Livestock Scale Reader (Tru-Test Incorporated, Mineral Wells, TX). The scale was designed with gates on both ends to allow for heifers to be weighed individually and easily be moved on and off the device (Figure 4).

Figure 3. Dairy heifers housed in individual pens.

Figure 4. Measuring the weight of dairy heifers used in the study.

Item	Hay	Haylage
Dry Matter, %	90.0	67.6
Crude Protein, %	18.2	19.3
Neutral Detergent Fiber, %	30.3	29.9
Acid Detergent Fiber, %	20.0	20.7
Metabolizable Energy, Mcal/kg	2.97	2.98
Net Energy for Growth, Mcal/kg	1.19	1.19
Calcium, %	1.00	1.11
Phosphorus, %	0.58	0.57
Magnesium, %	0.21	0.22
Potassium, %	1.40	1.45
Sodium, %	0.18	0.19

Table 1. Nutrient analysis of the dietary treatments fed to dairy heifers. Heifers were fed diets containing either 40% hay or 40% haylage on a dry matter basis.

Item	Hay	Haylage	SE	P-value
Starting Weight, kg	167.1	165.5	1.67	0.52
Ending Weight, kg	167.9	166.7	1.95	0.69
Dry Matter Intake, kg/d	4.83	4.71	1.10	0.44

Table 2. Body weight and dry matter intake of dairy heifers fed either dry hay or haylage diets.

Figure 5. Dry matter digestibility of dairy heifers' diet containing either 40% hay or 40% haylage on a dry matter basis.

RESULTS

The nutrient composition of the dietary treatments is provided in Table 1. Diets shown in Table 1 indicate that the only differences between the diets of hay and haylage were the dry matter percentage, with the other nutrients being almost the same. The heifers weighed an average of 166.3 kg at the start of the study and 167.3 kg at the completion of the digestibility study (Table 2). During the study, the heifers had little weight gain, which was unexpected. The lack of weight gain was most likely due to the change of housing and the variations in daily routines caused by the sampling protocol. Overall, the weight gain and dry matter intake were similar between the heifers fed hay and haylage during the study.

After determining the percent of chromic oxide in the feed and feces, the digestibility was calculated. The dry matter digestibility of the diets is shown in Figures 5 and 6. Diets containing hay had a 68.4% dry matter digestibility, while digestibility of the haylage diet was 66.6% ($P = 0.19$). The diets containing hay had an NDF digestibility of 68.4%, while haylage diets had an NDF digestibility of 66.1% ($P = 0.21$). In comparison, a study by Colucci, Chase, and Van Soest (1982) reported that haylage diets had an NDF digestibility of 67.5 and 65.0% for lactating cows on low-forage diets and high-forage diets, respectively, and 73.7 and 67.6% for dry cows.

Figure 6. Neutral detergent fiber (NDF) digestibility of dairy heifers' diet containing either 40% hay or 40% haylage on a dry matter basis.

Overall, the results of this study indicated the feeds were similar enough that the rumen microbes were able to utilize the feeds similarly. The averages of dry matter digestibility and NDF digestibility were similar regardless of whether the heifers were fed hay or haylage diets. The NDF digestibility does not vary much when looking at the diet fed or when comparing lactating cows to dry cows (Colucci, Chase, & Van Soest, 1982). A challenge of this study was the limited number of animals that were used. Including more animals in the study would have given us greater ability to test the results and would have been a means of improving the research. From this study, we can conclude that both hay and haylage have similar digestibility and, thus, are equally good sources of nutrients when raising young dairy heifers.

We can compare this research to other research done on dairy cattle: Borreani, Giaccone, Mimosi, & Tabacco (2007) also found that both hay and haylage were suitable methods for storing forages, and they saw an increase in milk production when cows were fed plastic-wrapped bale silage. Other researchers have found the digestibility of formic acid silage to be higher than that of hay (Waldo, Smith, Miller, & Moore, 1969), which is in contrast to the results of this study. However, this is the only research at this time that has compared feeding hay or haylage to young dairy heifers. Understanding whether feeding hay or haylage results in similar digestibility when feeding young dairy heifers is helpful for farmers to be able to make decisions when selecting feeds for their heifers. The most likely reason we saw similar digestibility in this study is because the nutrient concentrations in the hay and haylage are similar.

SUMMARY AND CONCLUSIONS

Feeding dairy heifers diets containing hay or haylage resulted in similar dry matter and NDF digestibility. Both hay and haylage appear to be viable options for feeding young dairy heifers.

Further research on forages could be used to help determine which forages and diets have the greatest digestibility. This information could be used by farmers and the industry to improve diet formulations and feeding strategies. Feeding more digestible diets to dairy heifers would allow the heifers to be able to grow faster with lower feed cost. Knowing the quality of diets would be helpful information for farmers so that heifer productivity could be improved.

ACKNOWLEDGMENTS

The author gratefully acknowledges graduate students Lea Pereira and Tana Dennis for their assistance and guidance throughout this project.

REFERENCES

- Borreani, G., Giaccone, D., Mimosi, A., & Tabacco, E. (2007). Comparison of hay and haylage from permanent Alpine meadows in winter dairy cow diets. *Journal of Dairy Science*, 90(12), 5643-5650.
- Brundage, A. L., & Sweetman, W.J. (1963). Hay vs. silage for two to six months old dairy calves weaned at 25 or 60 days. *Journal of Animal Science*, 22(2), 429-431.
- Colucci, P. E., Chase, L. E., & Van Soest, P. J. (1982). Feed intake, apparent diet digestibility, and rate of particulate passage in dairy cattle. *Journal of Dairy Science*, 65(8), 1445-1456.
- Hardison, W. A., Linkous, W. N., Engel, R. W., & Graf, G. C. (1959). Observations on the use of chromic oxide for estimating the fecal output of dairy animals. *Journal of Dairy Science*, 42(2), 346-352.
- Hopkins, B. A., & Whitlow, L. W. (2007). Feeding dairy heifers from weaning to calving. North Carolina State University Cooperative Extension. Retrieved from http://www.cals.ncsu.edu/an_sci/extension/dairy/203-dp65.pdf
- Lormore, M. 2005. The case for a quality dairy replacement program. In *Dairy calves and heifers: Integrating biology and management* (pp. 1-9). Ithaca, NY: Natural Resource, Agriculture, and Engineering Service, Cornell University.
- McGuire, R. L., Bradley, N. W., & Little, C. O. (1966). Effects of frequency of feeding on excretion of chromic oxide, crude protein, and gross energy, and on nutrient digestibility by steers. *Journal of Animal Science*, 25(1), 185-191.
- Schroeder, J. W. (2004). Haylage and other fermented forages. *North Dakota State University Cooperative Extension*. Retrieved from <http://www.ag.ndsu.edu/pubs/ansci/dairy/asl252w.htm>
- Stallings, C. C. (2011). Feeding cows with increasing feed prices: Efficiencies, feed options, and quality control. *Proceedings of the Florida Dairy Production Conference, Gainesville*, 47, 40-45.
- Waldo, D. R., Smith, L. W., Miller, R. W., & Moore, L. A. (1969). Growth, intake, and digestibility from formic acid silage versus hay. *Journal of Dairy Science*, 52(10), 1609-1616.