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Nutrient Management in Beef Feedlots and Forage Replacement with Byproduct and Crop Residues

Annie J. Doerr
University of Nebraska-Lincoln, adoerr@live.com

NUTRIENT MANAGEMENT IN BEEF FEEDLOTS AND FORAGE REPLACEMENT WITH BYPRODUCT AND CROP RESIDUES

By

Annie J. Doerr

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Advisors: Galen E. Erickson and Terry Klopfenstein

Finishing cattle performance and mass balance was evaluated when Micro-Aid was fed in diets containing wet distillers grains plus solubles (WDGS) at 35% (DM basis). Micro-Aid is a feed ingredient derived from a Yucca extract which contains saponins, and was included in the treatment diet at 1 g/hd daily in the supplement. There was no difference in performance and carcass characteristics between treatments. In the winter experiment, cattle fed Micro-Aid had a greater amount of OM and DM removed from the pen surface. Micro-Aid in the diet increased the amount of manure N and decreased N losses in the winter. The addition of Micro-Aid in the diet resulted in no difference in nutrient mass balance during the summer. There was no difference in N excreted in manure or lost via volatilization in the summer experiment.

Supplementing cattle grazing smooth bromegrass pasture with crop residue and byproducts may be a viable option to extend the grazing season or increase carrying capacity. Two experiments (2010 and 2011) were conducted to determine the effect on forage intake of supplementing cattle grazing smooth bromegrass pasture with a byproduct and crop residue blend. Cattle grazed at 1) the recommended stocking rate (7.56 AUM/ha in 2010 and 9.46 AUM/ha in 2011) with no supplementation (CON) or 2) double the recommended stocking rate (15.1 AUM/ha in 2010 and 18.9 AUM/ha in

2011) with supplementation (SUP). In experiment 1 (2010), nonpregnant, nonlactating cows grazed smooth bromegrass pasture from mid April to mid September. Supplemented cows were fed a 35% Synergy and 65% wheat straw mixture daily. The ensiled mixture (46.6% DM) was fed from late April to mid-August and a fresh mixture (30.7% DM; mixed at feeding time) from mid-August to mid-September. In experiment 2 (2011), cows with spring born calves at side grazed from early May to mid September. A fresh supplement of 30% MDGS and 70% cornstalk blend was fed daily. No differences in performance or diet quality were observed. Consequently, supplement replaced 40% of grazed forage intake in 2010 and 36.3% of forage intake in 2011. Supplementing by-product and crop residue mixtures can replace forage intake of cattle grazing smooth bromegrass pasture.

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Introduction

Nutrient management is a continuous environmental concern facing the feedlot industry, and with the feeding of distillers grains it is critical to understand its effects on nutrient management in open-dirt feedlot pens. Most cattle feeding operations pose a constant environmental concern as feed and manure nutrients are concentrated to a small area. Animals retain only a small fraction of nitrogen relative to their dietary intake. Once the animals' requirements are met, the excess nutrients are excreted (80-90%; Giger-Reverdin et al., 1999). Nitrogen volatilization from animal excreta into the atmosphere is a major challenge facing these typical feedlots, as well as nitrogen and phosphorus contamination of surface and ground water. Discovering options to reduce these losses and pollutants will prove beneficial to feedlots from a sustainability standpoint and additionally will increase manure value used as fertilizer.

Environmental Concerns

Nearly 75 – 80% of the beef feeding industry in the United States is concentrated in Nebraska, Kansas, Texas, Iowa, and Colorado. The USDA reported over 26 million cattle on feed, with 85% of these cattle fed in feedlots over 1,000 head capacity (USDA NASS, 2010). When a large number of cattle are concentrated to a small area, excess nutrients easily accumulate, leading to environmental concerns. Environmental concerns can be divided into three categories, concerns related to groundwater, surface water (eutrophication), and air (global warming, odors; Vasconcelos et al., 2007). In the US, domestic animal manure is the largest source of atmospheric NH_3 (Jongbloed and Lenis, 1998). With increased Environmental Protection Agency regulations to control these environmental issues, producers may see an increase in the cost of production by decreasing efficiency and/or potentially reduce the number of animals that can be produced to meet regulations in the future.

Nitrogen and P are crucial nutrients that are important nutritionally, environmentally, and economically. Since P is not volatilized, the majority of P excreted remains in the manure or runoff (Vasconcelos et al., 2007). However, excess N fed has the potential to volatilize from the pen surface. Nitrogen is considered the most critical manure element environmentally (Van Horn et al., 1996). However, in regions near critical lakes and streams where P in surface runoff is believed to enhance excessive algae growth, total farm P balance is considered more critical than N (Van Horn et al., 1996).

Nitrogen is lost through several processes, such as N-fixation, ammonification, denitrification, and nitrification. The ammonification of urea, through urine, leads to the escape of ammonia into the atmosphere. Urea can be rapidly hydrolyzed to form $(NH_4)_2CO_3$. The decomposition of $(NH_4)_2CO_3$ frees NH_4^+, which can volatilize as gaseous NH_3 (Vasconcelos et al., 2007). It has been estimated that approximately 50% of the N deposited on Nebraska feedlots may be lost as ammonia (Tamminga, 1996). On days favorable for volatilization during mid-summer when temperatures are above 20˚ C and humidity is high, a 50,000 head lot may release 10,000 kg/d of NH_3 N to the atmosphere (Tamminga, 1996). Additionally, when combined with other volatile compounds, NH_3 generates offensive odor emissions (Vasconcelos et al., 2007).

Ammonia can also undergo nitrification to nitrate (NO_3^-). Nitrate is very mobile in water, which creates concern for leaching into water reservoirs or ground water contamination (Vasconcelos et al., 2007). Problems also arise with denitrification of nitrate which causes the escape of nitrous oxide (NO_x) gas, which is detrimental to the ozone layer (Tamminga, 1996).

With stricter environmental regulations, there is a need to explore options to reduce the amount of N lost to the atmosphere. Additionally, manure can serve as a valuable fertilizer. Eghball and Power (1994) concluded that 50% of the N remaining in manure after volatilization is subject to loss in hauling, spreading, and incorporating manure into the soil. By improving nutrient composition, manure can be better utilized to meet the fertilizer needs of crop producers.

Nitrogen

The amount of N excreted is large relative to the amount that must be fed to optimize performance due to inefficiencies of converting N into tissue protein. Excess N that is not utilized for tissue gain is excreted, with the majority (80-90%) as urea in urine (Bierman et al., 1999). Dependent on diet, 25 to 50% of total N excreted is fecal N and 50 to 75% is urinary urea-N (Giger-Reverdin et al., 1991). Urea is rapidly hydrolyzed to CO_2 and NH_4 by urease and the resulting ammonia is easily volatilized. Volatilized N in the form of NH_3 from manure has the potential to return to the land or water via rainfall, dry precipitation, or direct absorption as well as contribute to the nuisance of odor and formation of particulate matter emissions (Vasconcelos et al., 2007).

Shifting N excretion from urine to feces may reduce ammonia losses from feedlots. The total amount of fecal N and OM can be altered by dietary carbohydrate sources and the degree of hindgut fermentation. Hindgut fermentation increases fecal N and decreases urinary N excretion (Bierman et al., 1999). Readily fermentable carbohydrates fed in feedlot diets can shift N to 50% fecal and 50% urinary (Bierman et al., 1999; Erickson and Klopfenstein, 2001). However, if high grain-based diets are fed (85% diet DM) then urinary N excretion increases (up to 75%; Bierman et al., 1999).

Phosphorus

Phosphorus is involved in a variety of functions in the animal, including building structure and strength of bones and cell walls, buffering systems, and energy transfer. The NRC (1996) overestimates the P requirement for cattle. Erickson et al. (1999, 2002) determined that P requirements for cattle are less than 0.16% of the diet DM for calf-fed steers and less than 0.14% (DM basis) for yearling steers. In both experiments, cattle performance was similar across all concentrations of dietary P. Because dietary P was not limiting animal performance Geisert et al. (2010) fed lower dietary P concentrations (0.10, 0.17, 0.24, 0.31, or 0.38% P). This study indicated heifers fed 0.10% P experienced a deficiency and the P requirement of finishing heifers is between 0.10 and 0.17% P. Common feedstuffs easily meet the animals' P requirements, so the excess P is excreted in the manure. Compared to N, P is much less subject to biological transformation and does not volatilize from the pen surface. Phosphorus runoff is the only route of P loss from the pen surface, accounting for less than 5% of total P excreted (Vasconcelos et al., 2007). Consequently, the majority (~95%) of P excreted is removed from the pen surface as manure. When manure is applied to crops on a N basis, P often exceeds crop requirements. Manure has a N:P content of 2:1, due in part to N losses and P being overfed; whereas, crops have a N:P requirement of 6:1 (Eghball and Power, 1994). Fertilizer (i.e. manure) is applied to first meet the crops' N requirement, which results in over-application of P. When P accumulates in the soil, its potential to leach and run-off is a concern for eutrophication. The eutrophication process promotes undesirable algae growth, which depletes the oxygen source for fish and other aquatic life during decay.

Manure Composition and Utilization

Manure composition varies depending on animal diet, duration of feeding period, soil contamination during pen cleaning, and season. The American Society of Agricultural and Biological Engineers (ASABE) provide characteristics for nutrient excretion by livestock based on 14 million cattle fed from 1996 to 2002. These standards indicate that a 554 kg finishing steer spending 153 days on feed (DOF) a diet with an average of 13.3% CP and 0.31% excrete 270 kg DM and 220 kg of OM. Nutrient composition of manure excreted included 24.8 kg N, 3.2 kg P, 9.2 kg K, 7.8 kg Ca, 1.8 kg Mg, 2.7 kg S, 19.4 g Cu, 68.9 g Fe, and 49.1 g Mn (Erickson et al., 2003). However, what is actually removed as manure will depend on animal housing. Manure removed from open feedlot pens includes soil removed during pen cleaning. In buildings with slatted floors manure removed is only what is excreted by the animal.

Kissinger et al. (2006) summarized mass balance data from open feedlot pens (244 pen means) from 18 experiments over a 10-year period. Soil was core sampled prior to trial initiation and at the conclusion to correct for nutrient concentrations on the pen surface. Manure characteristics were based off of two feeding periods, summer (May to September) and winter (November to May) in which cattle spent 128 or 166 DOF and finished at 575 and 601kg, respectively. During the summer feeding period 603 kg of

DM and 143 kg of OM was removed from the pen surface, compared to 1,453 kg of DM and 164 kg of OM in the winter. Additionally, manure contained 7.55 and 16.6 kg/steer N for the summer and winter, respectively.

Beef cattle manure can be effectively used for crop production and soil improvement because of its nutrient and OM content. Manure contains N, P, K, and micronutrients, which are necessary for plant growth. However, when P is overapplied it can cause water, air, and land pollution, because it contains excess nitrates, salts, undesirable microorganisms, pathogens, and greenhouse gases (Eghball and Power, 1994). Therefore, manure should be applied at rates that do not adversely affect the environment.

The addition of distillers grains plus solubles (DGS) to the diet poses challenges in terms of manure utilization, but also has potential to increase manure value as well as profit (Bremer et al., 2008). As DGS inclusion rates increase, manure management plans should address: 1) greater land requirements, 2) greater travel distances and time requirements for manure distribution, as well as labor and equipment needs and operating costs, and 3) management practices for minimizing soil erosion and runoff for fields receiving higher phosphorus-content manures (Regassa et al., 2008). The increased cost of manure management from feeding byproducts has the potential to be offset by increased manure fertilizer value. Fertilizer value of feedlot manure increases as the concentration of N and P increase in the diet. Bremer et al. (2008) evaluated the impact of feeding DGS on manure management and nutrient management plans and economics. As DGS increases in the diet, manure nutrient value increases, with 150,000 kg/year available crop N and 111,000 kg/year available crop P for 40% DGS compared to 99,000 and 58,000 kg/year for 0% inclusion of DGS in the diet. Thus, nutrient value is greater at the 40% level at $6.20/ton versus $3.50/ton at 0%. Considerations need to be made for land required, application cost, and time to apply manure when DGS is added to the diet. Increased inclusion of DGS from 0% to 40% increased land area to spread manure from 5,780 to 11,070 acres and application cost from $1.50/ton to $2.30/ton, respectively, as well as increased time to travel and apply manure. Consequently, net value calculated using the authors' inputs was $3.90/ton when DGS is added to the diet at 40%, compared to $2.00/ton for manure from diets not including DGS.

Wet Distiller Grains plus Solubles

During the dry milling process, sugar converted from corn starch is fermented by yeast to produce ethanol and CO_2. After the alcohol is distilled from the mash, coarse feed particles are left resulting in stillage. The coarser grain particles removed from the whole stillage can be sold as wet distiller grains (WDG) or dried and sold as dried distiller grains (DDG). The remaining liquid fraction of the stillage is evaporated to produce a syrup-like by-product containing 20 to 35% DM and is referred to as condensed distiller solubles (CDS). The CDS may be dried and added to DDG to produce dried distillers grains plus solubles (DDGS; 87-95% DM) and in the same manner added to WDG to produce wet distillers grains plus solubles (WDGS; 30-35% DM; Stock et al., 2000).

Producing distillers grains through the ethanol industry concentrates nutrients by about three-fold compared to corn. Following starch fermentation, about one-third of the dry matter remains as a feed product. Buckner et al. (2011) determined nutrient composition of WDGS and modified distillers grains plus solubles (MDGS; 45% DM) from 6 ethanol plants with 10 samples collected per day, across 5 d, and sampling was repeated over 4 separate months. Wet distillers grains were found to be about 31.0% CP and 0.84% P (DM basis). However, variation exists between plants and is somewhat variable within the same plant, with CP and P being less variable, especially when compared to fat and S. This variability may be attributed to processing differences among plants or the amount of solubles added to the distillers (Buckner et al., 2011).

Performance of cattle fed WDGS diets

When WDGS was evaluated by Vander Pol et al. (2006) at 0, 10, 20, 30, 40, and 50% of the diet DM replacing a HMC:DRC blend, final BW, DMI, and ADG increased quadratically, while G:F increased quadratically. Cattle fed 30% WDGS had the greatest ADG, with optimum feed efficiency at 40%. Regardless of WDGS inclusion level, energy values were greater than 100%, with values of 178, 138, 144, 137, and 121 for 10, 20, 30, 40, and 50% (DM) of WDGS in the diet (respectively; Vander Pol et al., 2006).

Replacement of corn up to 50% of the diet DM with WDGS results in superior performance compared to cattle fed no WDGS. In an updated meta-analysis by Bremer et al. (2010) using 46 treatment means and 2,534 steers fed in the winter, summer or fall. Seven trials fed a blend of HMC and DRC (1:1 ratio); seven trials fed DRC only; and one trial fed HMC without DRC. Wet distillers grains plus solubles replaced corn in the diets (0 to 50% of diet DM) in all trials. Although the feeding value of WDGS was consistently higher than that of corn, the feeding value was greater at lower WDGS inclusion levels and decreased as inclusion level increased. Energy values were 148, 142, 136, 129, and 123 for 10, 20, 30, 40, and 50% (DM) WDGS inclusion relative to no WDGS in the diet. These energy values were due to an improvement in ADG when

WDGS replaced corn. In addition, this meta-analysis concluded that there was no significant difference in feeding value when WDGS was fed to winter calves, summer yearling, or fall yearlings (Bremer et al., 2010).

Feeding WDGS diets and Nutrient Mass Balance

With considerable performance advantages including WDGS in the diet, it is commonly fed as an energy source. Consequently, N and P are fed in excess, which is excreted. Luebbe et al. (2009) conducted two experiments during the winter, calf-feds from November to May, and the summer, yearlings fed from May to October, to evaluate the impact of feeding WDGS in finishing diets on nutrient mass balance. Dietary treatments consisted of WDGS included in the diet at 0, 15, and 30% (DM basis) replacing corn (CON, 15WDGS, 30WDGS, respectively). Dry matter intake increased linearly with WDGS concentration in the winter experiment, but was not significant in the summer. In both experiments, ADG increased linearly with increasing inclusion of WDGS in the diet. Feed efficiency was not different among treatments in either experiment. Nitrogen intake linearly increased with inclusion of WDGS in both the winter and summer. In the winter, N retention decreased linearly with the inclusion of WDGS due to an ADG response, but was similar among treatments in the summer. As WDGS increased in the diet, N excretion increased. However, N removed in manure was not different among treatments in the winter, but increased linearly with WDGS concentration in the summer. Amount of OM removed was greatest for cattle fed 30WDGS in both experiments. Nitrogen lost via volatilization as a percentage of N excreted was not different among treatments in both the winter and summer experiment and averaged 68.3 and 77.0% respectively.

Luebbe et al. (2009) found that increasing dietary P with WDGS resulted in more P in the manure. As WDGS increased in the diet, P intake linearly increased. Retention of P linearly increased with WDGS concentration in the winter experiment due to an ADG response, but was not different among WDGS concentration for the summer experiment. In both experiments, P excretion linearly increased with increasing WDGS level. Feeding 15WDGS and 30WDGS increased the amount of P excreted by 32 and 64% in the winter (respectively) and 23 and 53% in the summer (respectively). Similarly, the amount of P removed in the manure during pen cleaning increased linearly in both experiments. Amount of P in runoff accounted for 3.8 and 8.0% of total P excreted for the winter and summer (respectively).

Speihs and Varel (2009) replaced corn with WDGS in the diet at 0, 20, 40, and 60% of the diet DM. Twenty-four steers were used in a 96 h nutrient balance trial that included total fecal and urine collection. Total P intake and P excretion increased linearly as the amount of WDGS increased in the diet. Phosphorus excreted in the feces was similar between the four dietary treatments; however, when WDGS replaced corn in the diet urinary P linearly increased. The same trends were observed with N. As WDGS inclusion level increased in the diet, N intake and excretion linearly increased. Nitrogen excreted in the feces was similar among dietary treatments, but urinary N increased linearly. Similarly, as WDGS increased in the diet, the proportion of total N excreted as urinary N increased linearly. Total N excreted was 110.2, 120.9, 150.2, and 174.6 g/d with urinary N representing 46.1, 51.1, 57.5, and 68.0% of total N excreted for the 0, 20, 40, and 60% WDGS diets, respectively.

Seasonal Variation

Differences in dry matter and organic matter removed

Kissinger et al. (2006) analyzed 18 mass balance studies from a 10-year period to compare seasonal variation in nutrient mass balance and characteristics and amount of manure from open feedlot pens. The DM amount of manure almost doubled from summer (May to September feeding period) compared with winter (November to May feeding period), increasing from 4.81 to 9.07 kg/hd/d respectively. Additionally, the amount of OM removed from the pen was twice as much for the winter compared with the summer feeding period (329 and 167 kg/steer, respectively). Greater amounts of DM removed from the winter feeding period are due to an increase in the quantity of soil removed with manure when hauled out of the pen. Wetter conditions in the winter promote soil and manure mixing from hoof action of the cattle. However, Luebbe et. al (2009) observed smaller differences in amount of DM removed between the winter and summer experiments. When WDGS was fed at 30% of diet DM in a corn-based diet, 1001 kg/hd of DM was removed during a 133 d feeding period in the summer (7.53 kg/hd/d) and 922 kg/hd during a 167 d feeding period during the winter (5.52 kg/hd/d).

Nitrogen Losses

There seems to be a trend among experiments in N losses in the winter compared to the summer. Differences (more positive N mass balance) were observed in the winter experiments of Erickson and Klopfenstein (2001), Adams et al. (2004) and Sayer et al. (2005), but not the corresponding summer experiments. Nitrogen losses can be highly variable with the time of year. With increasing ambient temperature, more NH_4^+ is converted to NH_3, resulting in greater volatilization losses. Dewes (1996) evaluated nitrogen losses at 20, 30, and 40˚C for 14 days and observed emissions at 9.0, 13.1, and 13.8% respectively. This research concluded that an increase in ambient temperature increased N losses. In Kissinger's summary, (2006) N volatilization averaged 47% during the winter feeding period and 69% in the summer months. When WDGS was evaluated in the diet at 0, 15, and 30%, (Luebbe et al., 2009) no differences were found in the percentage of N volatilized between treatments. However, N lost to volatilization as a percentage of N excreted averaged 68.3% for the winter and 77.0% for the summer.

Phosphorus removal

Phosphorus recovery varies significantly and is dependent on feedlot conditions prior to and during manure handling. Therefore, it may be difficult to determine the amount of P harvested in manure from the amount of P excreted. Kissinger et al. (2006) compiled data from six feedlots using a corn and by-product based diet with an average P content of 0.39% (DM basis). Data indicated an average of 9.8% P loss from the pen surface, with greater loss in the winter/spring (13.1%) compared to the summer/fall (6.4%). During the winter and spring months, feedlot surface conditions are wetter, and animal activity produces more mixing of manure and soil. Wet conditions also pose problems for operators harvesting only manure. Consequently, higher soil inclusion with manure solids may result in manure P exceeding excreted P. Another common practice of adding soil to the pen surface may cause manure P values to exceed P excretion. Manure P may be greater than P excretion if some P was removed at cleaning that was remaining in the pen from a previous group of cattle.

When Luebbe et al. (2009) evaluated the inclusion of WDGS in the diet (0, 15, and 30%) and its impact on nutrient mass balance, there was a difference in P recovery.

Correcting manure for soil P accounted for 98%, 79%, and 102% of excreted P in the winter and 87%, 62%, and 57% of excreted P in the summer for the 0, 15, and 30% WDGS diet, respectively. Lower P recoveries in the summer may be due to the dryer conditions when the pens are cleaned in the fall. In dry conditions P may not be removed because the soil is not as thoroughly mixed with the manure compared with wet conditions found in the spring cleaning (Luebbe et. al, 2009).

Methods to Reduce Nitrogen Loss

Increasing the C:N of feedlot manure has been successful in reducing the amount of N lost from the feedlot pen surface (Bierman et al., 1999; Erickson and Klopfenstein, 2001; Adams et al., 2004; Farran et al., 2006). Adding available C to the pen surface causes more microbial immobilization of NH_4^+. Carbon can be directly applied to the pen surface as sawdust or straw. Perhaps the most cost effective method to decrease N losses is by increasing C on the pen surface by manipulating the diet (Erickson and Klopfenstein, 2001). Shifting dietary fiber digestion to the hindgut increases the amount of fecal N and OM, as well as decreases urinary N excretion (Bierman et al., 1999). An increase of OM excreted increases C on the pen surface (Adams et al., 2004). Another method previously evaluated to reduce nitrogen losses is increasing pen cleaning frequency. The longer manure is exposed to the atmosphere, the potential of greater N volatilization increases (Adams et al., 2004. Wilson et al., 2004).

Indirect: Dietary Methods

Dependent on diet, 25 to 50% of total N excreted is fecal N and 50 to 75% is urinary urea-N (Giger-Reverdin et al., 1991). The fate of N excretion in the ruminant is dependent on the degree of hindgut fermentation, which is directly affected by the dietary carbohydrate source. Increasing dietary fiber limits digestion in the rumen and small intestine shifting fermentation to the hindgut, increasing fecal N and decreasing urinary N excretion. Non-structural carbohydrates, such as corn starch, are rapidly degraded in the rumen so it is not available for fermentation in the hindgut. However, fiber sources including roughages and fibrous corn byproducts, do not completely digest and are available for hindgut fermentation. Microbes in the hindgut recycle urea across the intestinal wall to meet their protein needs. Consequently, N excretion shifts from urine to a more stable organic form (microbial protein) in feces, resulting in more fecal N.

In one of the first mass balance experiments to evaluate decreasing diet digestibility in feedlots, Bierman et al. (1999) focused on the effect of source and level of dietary fiber on N and OM excretion. Treatments consisted of 1) wet corn gluten feed (WCGF; 41.5% diet DM) and 7.5% roughage 2) 7.5% roughage (7.5% R) and 3) no roughage in the diet (CON). Nitrogen intake was greatest for the WCGF diet, intermediate for 7.5% roughage, and lowest for CON. Because N retention was similar, cattle on the WCGF diet excreted the most N followed by the 7.5% R, and the least for CON (20.8, 18.5, and 16.3 kg respectively). Nitrogen removed in the manure followed a similar response as N excretion, with the greatest for cattle on the WCGF diet (3.9 kg), intermediate for 7.5% R (2.3 kg), and lowest for CON (1.5 kg). Organic matter excretion was greatest for steers fed WCGF, followed by 7.5% R and CON (269, 172, and 114 kg respectively).

Corn silage inclusion was evaluated by Erickson et al. (2000) to determine its potential to increase manure N and decrease N losses via volatilization. Corn silage was fed at 15, 30, and 45% of diet (DM) in two feedlot studies (winter and summer) and digestibility trial. Diets were formulated to meet MP requirements, so in each diet MP was overfed by the same amount. In the yearling summer feedlot and digestibility trial, HMC was added to the diet (10% DM) to maintain a calculated UIP balance across the three levels of silage. In the calf-fed winter experiment overfed UIP was kept constant across levels by adding feather and blood meal. Ruminally and duodenally cannulated steers were used in a 3x3 Latin square digestibility trial. Organic matter and N intake decreased as inclusion level increased, due to lower intakes as corn silage increased in the diet. Dry matter, OM, and N digestibilities were not affected by silage level, contrary to the authors' hypothesis that DM and OM digestibility would decrease linearly as inclusion level increased. The difference in grain source may have contributed to an unexpected increase DM and OM digestibility for the 45% silage treatment which included HMC. In the summer yearling experiment, N and OM removed in manure was quadratic, with more N and OM removed from the 30% silage treatment than the 15 and 45%. Level of silage did not affect N excreted or loss via volatilization with an average of 59% lost. In the winter calf-fed study, N and OM intake linearly increased as silage increased from 15 to 45% of the diet DM, which reflects differences in DM intake. Organic matter excretion was quadratic, with more OM excreted from cattle fed the 30 and 45% silage treatments. Additionally, OM in manure increased linearly as corn silage was increased in the diet; however, N volatilized was not different among treatments. Therefore, these studies show that the 30 and 45% silage treatments did not affect N volatilization when more OM was removed in manure from these treatments. Furthermore, ADG and G:F decreased when corn silage was added from 15 to 45%, with a quadratic response observed in yearling experiment and linear decrease for the calf-feds.

Erickson and Klopfenstein (2001) evaluated feeding three levels of corn bran (0, 15, and 30% of the diet DM) and its affect on OM excretion and N losses. Corn bran is a by-product of the wet milling process, which contains high concentration of neutral detergent fiber (NDF) that is readily digested but has lower digestibility (80.3%) compared to corn (84.5% DM digestibility; Scott et al., 1998). In a digestibility trial using cannulated steers, OM digestibility decreased linearly from 77.3 to 73.1% of OM intake as bran inclusion increased in the diet. Cattle excreted more N in feces as bran increased, at 61, 66, and 70 grams/day for 0, 15, and 30% bran, respectively. This indicates that fiber digestion shifted more towards hindgut fermentation, increasing fecal N.

These diets were also evaluated on a pen-size scale. Nitrogen intake increased with increasing level of corn bran in the diet. Since N retention was not affected by dietary treatment, N excretion followed a similar response as N intake. Seasonal variation, as stated earlier affects volatilization, was observed in this experiment. In the winter/spring, OM removed was 51% and 105% for cattle fed 15 and 30% corn bran (respectively) compared to cattle consuming 0% bran. When corn bran was fed at 15% of the diet, manure N increased by 68% compared to the 0% bran. At 30% of the diet, manure N almost doubled (98% increase) compared to feeding 0% bran. Increasing dietary bran linearly reduced N lost via volatilization at 74.1, 59.8, and 53.8% for the 0, 15, and 30% bran treatments, respectively. However the manure C:N ratios were similar across dietary treatments. This suggests that more N was contained in the manure of the diets including corn bran because more manure was removed. In the summer months, corn bran in the diet had no effect on N in manure, N in runoff, or N volatilized from the pen surface. Compared to the 0% bran treatment the amount of OM removed in manure increased by only 15 and 25% for the 15 and 30% corn bran diets, respectively. Although there was not a difference on N losses, the C:N ratio increased in manure. These data suggest that feeding corn bran in the diet can have varying results depending on the time of year. Adding corn bran to the diet has the potential to reduce N losses in the cooler months. However, as bran level increased in the diet, performance was depressed in both the winter and summer experiments. Average daily gain and feed efficiency linearly decreased as bran level increased. Feed efficiency decreased 7.8% when 0-bran was fed compared to 15-bran, and an additional 2.8% decrease at 30-bran. Based on efficiency, corn bran provided less energy compared with corn (Erickson and Klopfenstein, 2001).

Sayer et al. (2005) also evaluated the effects of decreasing digestibility of a finishing diet by replacing DRC with corn bran, as well as combinations of corn bran and steep which are normally combined in the production of WCGF. Two experiments were conducted (winter and summer) in which dietary treatments consisted of 1) conventional corn diet (75% DRC; CON), 2) DRC replaced by 30% corn bran and 0% steep (30/0), 3) DRC replaced by 30% bran and 15% steep (30/15), and 4) DRC replaced by 45% brand 15% steep (45/15). In both experiments, the inclusion of by-products resulted in more manure N and OM removed. In the winter, the 45/15 treatment reduced N losses by 43.9% when compared to the CON diet. However, in the summer experiment, byproducts in the diet had no effect on the amount of N lost. In this study, the addition of steep helped cattle maintain performance when bran was added to the diet.

Direct: Increasing Carbon on the Pen Surface

Adding carbon to the pen surface has the potential to increase N removed in the manure. Increasing the C:N ratio increases the tendency to retain more N in the manure. Adding C to manure decreases N losses by lowering pH when stored anaerobically or by microbial immobilization when stored aerobically (Erickson and Klopfenstein, 2001). One proposed method to increase C on the pen surface is by adding sawdust. Lory et al. (2002) added sawdust to the pen surface in the summer at a 2:1 ratio of sawdust to fecal dry matter. When C was added to the pen surface, manure N increased by 78% compared to no sawdust application and decreased N loss by 21%.

Corn milling byproducts are a common indirect method used to increase the C:N ratio on the pen surface through manure. Adams et al. (2004) compared the effects of OM addition by feeding less digestible diets or adding sawdust on N losses in the winter and summer. Treatments consisted of 1) conventional diet with 75% DRC and no OM application (CON) 2) 30% corn bran and no OM added to the pen surface (BRAN) and 3) sawdust applied to the pen surface of cattle fed a conventional diet (SAWDUST). During the winter experiment, N intake was similar among treatments. Calves fed BRAN retained less N than CON and SAWDUST cattle due to lower ADG and final BW. As a result, BRAN calves excreted more N than CON and SAWDUST. Organic matter intake was similar between diets, however, feeding BRAN resulted in an increase in OM excretion compared with CON and SAWDUST groups. The BRAN and SAWDUST treatments resulted in 6.2 and 7.5 kg/steer less N lost to volatilization, respectively.

Relative to the CON, BRAN decreased the amount of N lost by 38%, whereas SAWDUST decreased N lost by 45%. The same treatments were imposed in a summer experiment, in which N intake, retention, and excretion were similar between groups. However, BRAN and SAWDUST treatments imposed during the summer months did not significantly reduce N loss compared with CON (16.3, 15.1, and 17.2 kg/steer N lost for the CON, BRAN, and SAWDUST treatments, respectively).

Pen Cleaning Methods

Increasing pen cleaning frequency reduces the amount of time manure is exposed to the environment, reducing the amount of N lost through volatilization. Before pens are cleaned, it is estimated that 50 to 75% of total N excreted is lost (Eghball and Power, 1994).

Adams et al. (2004) evaluated feeding corn bran in the diet at 30% DM (BRAN) compared to a conventional corn diet (30% DRC and 45% HMC; CON) during the winter with two imposed pen-cleaning frequency treatments. Pens were either cleaned once at the end immediately upon cattle removal or five times. This treatment consisted of four pen cleanings (monthly) during the feeding period and once at the end after cattle removal. When cleaning pens was imposed, feeding BRAN resulted in a noticeable reduction (5.8 kg/steer) in N losses via volatilization. However, when pens were cleaned once at the end of the feeding period, N losses were greater for cattle fed BRAN than the CON diet. Consequently, these findings indicate that increasing pen cleaning frequency for cattle fed BRAN decreased N losses as opposed to allowing manure to collect on the pen surface during the entire feeding period. Nitrogen losses were reduced by 44% when pens were cleaned monthly and BRAN was fed compared with the CON.

Wilson et al. (2004) evaluated the impact of pen cleaning frequencies on N loss in two consecutive summers (2001 and 2002). Pens were cleaned monthly (every 28 days) or end-of-the-feeding period pen cleanings. The amount of DM, OM, and N removed increased when pens were cleaned monthly. By cleaning pens monthly, N removal increased by 3.95 and 2.49 kg per steer or 69.0 and 34.8% above manure N removed at the end of the feeding period (2001 and 2002, respectively). Additionally, monthly cleaning reduced the total N loss via volatilization by an average of 14% for both years.

Rich et al. (2011) compared imposed pen cleaning frequency treatments to either a 75% WDGS and 5% straw (diet DM; WDGS + straw) or a corn-based diet of 85% DRC and 5% straw (CON). Pens were cleaned after steers were removed for harvest or every 28-days (monthly). This experiment was conducted during both the winter (November – May) and summer (May – November) months. There were no interactions between dietary treatments or pen cleaning frequency. The amount of DM and OM was greater when pens were cleaned monthly rather than at the end during the winter feeding period, however there was no difference in N lost. In the summer experiment, monthly pen cleaning almost doubled the amount of N, DM, and OM removed in the manure. Additionally, increased pen cleaning frequency reduced N losses by 50.5% compared to cleaning at the end of the feeding period.

Saponins

Function in the Rumen

Saponins are natural detergents (surfactants) extracted from *Yucca schidegera* and contains a steroid nucleus (fat-soluble) and side chains of water-soluble carbohydrates. In the rumen, saponins form irreversible complexes with cholesterol in the protozoal cell membrane, causing breakdown of the membrane, cell lysis, and death (Cheeke, 2000). Ciliate protozoa prey on rumen bacteria. Proteolysis of bacterial protein increases ruminal ammonia concentrations (Cheeke, 2000). Wallace et al. (2004) studied the effects of *Yucca schidegera* in the rumen in vitro utilizing rumen fluid from sheep fed a 50% hay, 30% barley, 10% molasses, and 10% fishmeal diet. The addition of *Y. schidegera* to rumen fluid yielded a reduction of movement by ciliate protozoa. Addition of *Y. schidegera* at 0.1% of diet DM decreased bacterial breakdown by 22% and when added at 1% caused bacterial breakdown to stop as a result of decreased protozoa activity. A reduction of ciliate protozoa not only has the potential to improve microbial yield and increase protein flow to the ruminant, but also reduce ruminal ammonia concentrations.

Wu et al. (1994) utilized ruminally and duodenally cannulated dairy cows to determine the effect of Yucca extract on ruminal digestion, fermentation, and ammonia patterns. Deodorase was used in this experiment and contained 30% *Yucca schidgera* extract (70% inactive carriers). Yucca extract administered into the rumen of dairy cows fed diets containing 1.2% urea at 8 g/d had no influence on ruminal NH_3 N concentrations, pH, or volatile fatty acids. Ruminal digestion of orgainic matter, acid detergent fiber, crude protein or microbial protein entering the duodenum was not affected by the addition of 4g/d of yucca extract. In this experiment no differences were observed for ruminal fermentation characteristics with the addition of Yucca extract.

In a 61% barley and 38.5% alfalfa silage diet, Hristov et al. (1999) evaluated the effects of intrarumenally injecting 0, 20, or 60 grams of *Yucca schidgera* extract. Protozoa were 42% less numerous in cattle receiving 20 g of Yucca extract than the control heifers. However, a higher dose did not further reduce the protozoal population. In this experiment, the addition of yucca extract had no impact on the amount of N intake, excretion, or retention by the animal. Yucca extract appeared to influence the bacteria populations of the rumen, increasing the propionate ratio. Total VFA concentration was not affected by the addition of yucca, with 80.7, 83.1, and 83.8 mM for the 0, 20, and 60g treatments, respectively. Still, propionate increased (16.5, 19.3, and 19.5 mM) and the acetate:propionate ratio decreased (3.13, 2.85, and 2.77 for 0, 20, and 60 g, respectively). *Selenomonas ruminantium* is responsible for most of the propionate production in the rumen, but the growth of *S. ruminantium* is not affected by yucca saponins (Wallace et al., 1994). However, the growth of other species such as *Streptococcus bovis* and *Butyrivibrio fibrosolvens* was inhibited. Consequently, the increase of propionic acid in the rumen in this study may have been the result of Yucca extract inhibiting bacteria and protozoa not involved in propionate production in the rumen and promoting *Selenomonas ruminantium* to fill the niche.

To determine the effect of adding *Yucca schidgera* extract (YSE) in diets on methane production Micro-Aid (DPI Global, Porterville, CA) was used in an *in vitro* study, with rumen fluid from cattle fed an all forage diet, a 50:50 forage:concentrate diet, and 10:90 forage:concentrate diet (Xu et al. 2010). Gas emission from each fermentation vessel was measured continuously by an automated pressure transducer system. Yucca extract (Micro-Aid) was added at 110 mg/kg diet. In all diets, the inclusion of Micro-Aid decreased methane proportion and production. One proposed method for methane reduction is the protozoa/methanogen interaction in the rumen. It is thought that YSE decreases rumen protozoal numbers, which reduces methane. Yucca extract may also affect methane produced by inhibiting H_2 production, particularly through inhibition of specific microbes.

Effects of Saponins on Performance in Cattle Diets

Saponins fed in feedlot diets show mixed results on performance. When fed a 82% concentrate finishing diet and sarsaponins (Sevarin) was included at 250 mg/head/day for the first 14 days and 500 mg/head/day for the remainder of the feeding period, no performance benefits from feeding Sarsaponin was observed (Dorn, 1985). During the first 28 days of an 82 day feeding period, steers fed Sarsaponin showed a greater ADG response, but did not continue for the remaining of the feeding period.

Mader and Brumm (1987) followed this study by conducting4 experiments to determine the effect of feeding Sarsaponin, steroid saponin in *Yucca schidigera* plant extract, in feedlot receiving diets containing 1) soybean meal (SBM), 2) 1% urea (UR), 3) 1% urea plus Sarsaponin (URS) or 4) SBM plus Sarsaponin (SBMS) as the primary source of supplemental protein in a corn and corn silage diet. Sarsaponin was fed for 28 days only at 150, 120, 150, and 150 mg/head/day for trials 1, 2, 3, and 4, respectively. Inclusion of Sarsaponin with urea improved gains (0.739 kg/d) compared to urea (0.658 kg/d), however superior performance (0.839 kg/d) was observed in cattle consuming the diet containing SBM as a protein source. When fed with SBM as a protein source, Sarsaponins had no significant difference on performance. Consequently, this lack of a sustained response suggests that Sarsaponin does influence urea metabolism.

Nichols et al. (2011) included a yucca saponin (Ruma-Just, Nova Microbial Technologies) in a steam-flaked corn (71.9%) and WDGS (11%) finishing diet at 1.0 g/steer daily. Ruma-Just did not significantly impact finishing performance. However, cattle fed Ruma-Just had increased marbling, but this did not translate to differences in quality grade data.

Saponins added to ruminant diets have shown to reduce protozoal movement and populations in the rumen (Cheeke, 2000; Wallace et al., 2004; Hristov et al., 1999; Xu et al., 2010). In response, propionate producing bacteria, *S. ruminantium*, fills the niche (Hristov et al., 1999). A reduction of ciliate protozoa also has the potential to improve microbial yield and increase protein flow to the ruminant (Wallace et al., 2004). However, the addition of yucca extract has shown no pertinent increase in performance results (Mader and Brumm, 1987; Nichols et al., 2011).

As DGS continue to be a common component of feedlot diets increasing nutrient intake by the animal, the excess amount of N excreted and lost from the pen surface poses environmental challenges. Consequently, investigation of methods to reduce N losses is crucial. Dietary manipulation and addition of OM to the pen surface has proven to be successful at decreasing N losses, however seasonal variation exists with more positive mass balance results in the winter, but not in the corresponding summer experiment. Therefore, two experiments were conducted during both the summer and winter to account for changes in temperature and its effects on mass balance. Saponins have not shown to effect performance or carcass composition, but may alter the rumen environment. Our hypothesis was that the inclusion of Micro-Aid would have no effect on performance and carcass characteristics or nutrient mass balance when fed in a cattle finishing diet. This study was conducted to determine the effect of feeding saponins (Micro-Aid) in diets containing WDGS on finishing cattle performance and nutrient mass balance.

Review of the Literature II

Introduction

Supplementing cattle on pasture may extend the grazing season or allow producers to increase carrying capacity. Crop residues on farms with cool-season grass pasture appear to be economical sources of fiber to feed during the summer to substitute for grass consumption. Purchasing and(or) storing by-products during the summer can be economical for producers. Mixing byproducts with low quality forages can increase the palatability of the forage, and the bulk from the forage can provide a fill effect that potentially reduces grazed forage intake.

The objective of this study was to determine the effect on forage intake of supplementing cattle grazing smooth bromegrass pasture with a by-product and low quality forage blend. Observations were made concerning the ratio of by-product to low quality forage throughout the grazing season, as well as palatability issues related to ensiled or fresh mixtures.

Forage

Smooth bromegrass (*bromus inermis*) is a common cool-season grass utilized for grazing in eastern Nebraska. It grows rapidly in the late spring and fall regrowth appears in early summer. Nutritive value is greatly affected by stage of maturity and seasonal climatic conditions. A three year study conducted by Greenquist et al. (2009) using fistulated cattle showed protein values ranging from 13.3 to 18.8% from the end of April to September for smooth bromegrass pasture. Lowest CP values were observed during the summer months of June and July, with higher CP in the early growing stages and later in the season. Similarly, MacDonald et al. (2007) found average CP values throughout the grazing season, May to August, of 20.9%. Watson et al., (2011) observed a quadratic effect of CP value of smooth bromegrass, with values of 18.6, 14.4, and 16.1% for the months of May, July, and September, respectively.

Neutral detergent fiber (NDF) is an estimation of cell wall content, including cellulose, hemicelluloses, pectin, silica, and lignin (Van Soest, 1982). Plant maturity directly affects NDF content and plant digestibility. As grasses mature, the proportion of cell wall increases while the proportion of cell contents decrease. Additionally, the stem to leaf ratio increases, leading to an overall decrease in forage quality (Greenquist et al., 2009; Watson et al., 2011). In the same way, as the growing season progresses, digestibility decreases with a slight increase at the end of the grazing season. At the beginning of the grazing season in late April, Greenquist et al. (2009) reported IVDMD values of 71.6% with gradually decreasing values to 54.6% in late July and August. However, there tended to be a slight increase after this period with a value of 57.1% in September. The most recent data from these same pastures mirrors this pattern in which IVDMD values were 68.1% at the beginning of the grazing season in late April, 57.9% at the midpoint, and 53.7% at the end in September (Watson et al., 2011).

By-products

During the dry milling process, sugar from corn is fermented by yeast to produce ethanol and CO_2. After the alcohol is removed from the stillage, the coarser grain particles are removed and can be sold as wet distillers grains (WDG), partially dried and sold as modified distillers grains (MDG), or fully dried and marketed as DDG. The remaining liquid fraction of the stillage is evaporated to produce a syrup-like by-product containing 20 to 35% DM and is referred to as condensed distiller solubles (CDS). The

CDS may be dried and added to DDG to produce DDGS (87-95% DM) and in the same manner added to MDG resulting in MDGS (42-50% DM), or WDG to produce WDGS (30-35% DM) (Stock et al., 2000).

Following starch fermentation, about one-third of the dry matter remains as a feed product. Therefore, producing distillers grains through the ethanol industry concentrates nutrients by about three-fold compared to corn (Klopfenstien et al., 2008). Distillers grains are about 31.0% CP and 0.84% P (Buckner et al., 2011). Additionally, oil is not removed in most dry milling processes; thus, distillers by-products are higher in fat relative to corn, with an average value of 11.8% (Buckner et al., 2011). The protein fraction called corn gluten meal is also not removed during processing, so distillers grains contain high levels of escape protein, about 65% UIP (Stock et al. 2000). However, variation in nutrient composition exists between plants and is somewhat variable within the same plant, and may be partially due to the difference in the amount of solubles added back to wet grains (Buckner et al., 2011).

Corn gluten feed (CGF) is a byproduct of the wet milling process. In this process, high quality corn is steeped then separated into kernel components of corn bran, starch, corn gluten meal, germ and soluble components. Bran and steep liquor are the major components of CGF (Stock et al., 2000). The nutritive profile of CGF varies depending on plant and is highly variable with the amount of steep liquor added, which is high in energy (136% the feeding value of corn) and protein (35%; Erickson et al., 2010). Wet corn gluten feed (WCGF) has a wide DM range from 40 – 60%, and contains 16-23% CP, which is approximately 70% ruminally degradable protein. The majority of WCGF averages 20% CP, 38% NDF, and 0.66% P (Stock et al., 2000; Erickson et al., 2010).

Golden Synergy is a 40% MDGS and 60% WCGF co-product blend (47-50% DM) produced by ADM (Columbus, NE). It has a nutritive composition of 23.8% CP, 38.1% NDF, 8.1% fat, and 0.77% S (Dib et al., 2010).

Use of by-products in forage based diets

By-products' palatability and nutritive profile make it an attractive supplement for grazing cattle. Distillers grains can serve as a valuable supplement for grazing yearlings from a cattle performance and forage replacement standpoint. Forage replacement rate can be defined as the unit reduction in forage intake per unit of supplement consumed (MacDonald et al., 2007). Increasing DDGS levels of supplementation to heifers grazing smooth bromegrass increased ADG (MacDonald and Klopfenstein, 2004). In this study, heifers were supplemented at 0, 1.0, 2.1, 3.1, and 4.2 lb while grazing smooth bromegrass pasture. One kg of DDGS replaced 1.72 kg of forage in this study. In another experiment, by the same authors, it was found that supplementing DDG from 0.50 to 0.75% of BW daily to yearling cattle that would consume 2.0% of BW when not supplemented replaced grazed forage at a rate of approximately 50%, which equates to a possible 10 to 20% increase in stocking rate (MacDonald et al., 2007).

Cattle consuming actively growing forages will respond to UIP supplementation (DGS), because the protein in the forage is highly degradable in the rumen, causing a MP deficiency (MacDonald et al., 2007). Additionally, the fat content of the DGS can give an energy response. In a summary of eight grazing experiments with yearlings supplemented at 1.81 or 3.40 kg of DGS, Klopfenstein et al. (2007), found that daily gains were increased by 0.24 and 0.40 kg/day. Additionally, it was estimated that every

1.0 kg of DGS decreased forage intake by 0.5 kg. The overall response in these studies appears to be a combination of both a protein and energy response.

In a meta-analysis conducted by Griffin et al. (2009), increasing DDGS supplementation quadratically increased ADG and final BW in both pasture and pen studies. Feeding DDGS decreased forage intake quadratically; however increased level of supplementation increased total intake quadratically. Pen studies showed a greater ADG response than pasture studies to DDGS supplementation. This response may be due to differences in protein (MP) requirements. Cattle were lighter and younger at trial initiation in the pen studies, leading to greater MP requirements.

Forage replacement with the use of by-products and low quality forage

Mixing low quality forage and by-products has potential to replace forage. Crop residues or low quality forage are high in fiber and low in energy. When this type of diet is fed to the animal, intake is limited by physical capacity of the animal, or stretch of the gastrointestinal organs. The moisture and physical characteristics (stickiness) of DGS enhance palatability and reduce separation and sorting of less palatable ingredients (Klopfenstein et al., 2008). Therefore, by-products enhance the palatability of the blend, while the low quality forage can provide a fill effect.

In 2007, Nuttelman et al. conducted an experiment with 3-year old, non-gestating, lactating beef cows with spring born calves at side, grazing native range to determine the effect of grass intake when pairs were supplemented WDGS and grass hay (DM). Treatments consisted of: 1) the recommended stocking rate of 1.48 AUM/ha with no supplementation (CON1); 2) double the recommended stocking rate (2.96 AUM/ha) and supplemented 6.62 kg/head daily (50% of estimated DMI) of 55% grass hay and 45%

WDGS (DM; SUP); and 3) double the recommended stocking rate (2.96 AUM/ha) with no supplementation (2X). Supplemented cows outgained CON1 and 2X cows by 0.70 kg and 0.77 kg per day, respectively. The amount of forage that disappeared per cow/calf pair on a daily basis was similar among treatments. Supplemented cattle consumed 6.71 kg/day of the WDGS and grass hay mixture. In this study 1 kg of the mixture replaced 0.22 kg of grazed forage (Nuttelman et al., 2010).

In a subsequent study conducted in 2008 by the same authors using a similar design, three blends of a 50:50 (HIGH), 60:40 (MED), and 70:30 (LOW) WDGS and wheat straw were fed. Mixtures were stored in silo bags 30 days prior to initiation of the trial with all mix moisture levels at 50% DM. Supplemented cattle were stocked at a rate of 2.96 AUM/ha and the non-supplemented (CON) cattle at the recommended stocking rate of 1.48 AUM/ha. There were no significant differences in final body weight or ADG among the treatment groups. Non-supplemented cattle had significantly less percentage utilization of available forage than HIGH and MED (34.4, 46.0, and 44.3 %, respectively). However, CON and LOW did not differ in percent utilization of available forage. The lower quality wheat straw used in 2008 replaced a larger proportion of grazed forage intake than the grass hay used in 2007, most likely related to the higher fiber content of the wheat straw and lower digestibility. The 70:30 wheat straw:WDGS blend nearly replaced grazed forage intake on a 1:1 basis (Nuttelman et al., 2010).

Villasanti et al., (2009, 2010) followed these studies by evaluating different blends of WDGS with a low quality forage, grass hay or straw, fed to yearling steers. Treatments consisted of: 1) Control at the recommending stocking rate (1.68 AUM/ha in 2009 and 1.64 AUM/ha in 2010), 2) double stocked (3.18 AUM/ha in 2009 and 3.26

AUM/ha in 2010) supplemented with a mixture consisting of 60% straw and 40% WDGS (STRAW), 3) double stocked (3.30 AUM/ha in 2009 and 3.28 AUM/ha in 2010) supplemented with 60% hay and 40% WDGS (LOW), and 4) double stocked (3.26 AUM/ha in 2009 and 3.25 AUM/ha in 2010) consuming a supplement made of 70% hay and 30% WDGS (HIGH). Supplemented cattle were fed at a targeted rate of 1.15% BW on a DM basis, which represents about 50% of their daily intake. Mixtures were stored in silage bags 30 d prior to the initiation of the trial, and all mixes were 50% moisture. In 2009, ADG for the CON and HIGH treatment were similar, but LOW steers outgained CON and HIGH steers by 0.16 and 0.12 kg per day respectively, whereas steers on the STRAW treatment outgained CON and HIGH steers by 0.15 and 0.12 kg per day, respectively. In 2010, steers supplemented the 60% straw and 40% WDGS mix gained 0.21, 0.14, and 0.23 kg/d less than the CON, HIGH, and LOW steers respectively. Supplementation resulted in 1 kg of the LOW, HIGH, and STRAW treatments replacing 0.52, 0.51, and 0.52 kg of range forage, respectively (Villasanti, 2010).

When evaluating the effect of storage method and forage type on grass hay replacement, Weber et al. (2012) found that growing steers had a greater DMI for non-ensiled MDGS:crop residue blends compared to the ensiled mixes. Supplement substituted grass hay by 33.7, 35.4, 29.0, and 9.6% for the fresh cornstalk, ensiled cornstalk, fresh wheat straw, and ensiled wheat straw mixtures, respectively.

Fresh vs. Ensiled Mixtures

Feeding ensiled or non-ensiled (mixed fresh at time of feeding) by-product and low quality forage mixtures has shown mixed results. Problems with quality deterioration with ensiled blends may lead to palatability issues.

Wilken et al. (2009) fed varying levels of a WDGS and corn stalk blend in a growing diet and evaluated the differences in performance when fed an ensiled (20 days before trial initiation) or fresh mixture. Steers fed the ensiled mixture had greater DMI intakes than those fed the non-ensiled blends, with 6.39 and 5.53 kg/day, respectively. Additionally, cattle fed the ensiled mix had greater ADG. This response was mirrored by a study by Weber et al. (2012), in which individually fed steers had ad libitum access to either an ensiled or fresh mixture of a 30:70 MDGS:low quality forage blend. Wheat straw and cornstalks served as low quality forage. Steers fed the MDGS and ensiled wheat straw mix had greater ADG and DMI than steers fed fresh mix. However, feed efficiency improved for cattle fed the fresh cornstalk mixture rather than the ensiled cornstalk blend.

In a growing study conducted by Buckner et al. (2010)**,** WDGS was mixed with straw at 30 or 45% of the diet DM and fed as a fresh or ensiled mix. Fresh blends were mixed every other day and ensiled mixes were bagged 70 days prior to trial initiation. Cattle fed the ensiled mix had a greater ADG and were more efficient than cattle fed the fresh mix. These enhanced performance results suggest improved rate or extent of fiber digestion, which may be due to the ensiling of the straw fiber.

In a follow-up study on a pen-size scale, Weber (2012) investigated the palatability of MDGS and crop residue mixes by evaluating the effect of these storage methods and forage types. However, in this study, steers consuming the fresh 70% moisture mixtures had greater intakes than those fed the ensiled mixture. The lowest forage replacement was observed for cattle fed the 70% ensiled moisture supplement.

Lower intakes for cattle fed the ensiled wheat straw mixture may be attributed to spoilage within the silo bag due to slow rates of feeding.

With the availability of co-products and low quality forages, producers should consider supplementing grazing cattle with these mixes with the potential to increase stocking rates or extending the grazing period. By-product and low quality forage or crop residue mixes have proven to be successful replacing forage intake to some extent in both a grazing and pen setting without sacrificing performance. There are mixed results concerning preference of ensiled versus non-ensiled or fresh mixes. Consequently, evaluating these methods as well as observing other palatability issues is critical to effectively replace forage intake.

Low forage and by-product mixes were successful in replacing forage intake for cattle grazing native range in the Sandhills (Nuttelman et al., 2010; Vilasanti, 2010). However, native range is dominated by warm season grasses compared to Eastern Nebraska where the majority of pastures are a smooth bromegrass monoculture. Additionally, the availability of crop residue in Eastern Nebraska as well as by-products make it an attractive supplement during the grazing season. Therefore, our objective was to determine the effect of supplementing cows grazing smooth bromegrass pasture with a low quality forage and by-product blend on forage replacement. Additionally, this study was designed to investigate palatability issues of feeding a fresh or ensiled mixture.

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CHAPTER II

Effect on Performance and Nutrient Mass Balance of Feeding Micro-Aid in Wet Distillers Grains Plus Solubles Diets

A. J. Doerr*, G. E. Erickson*, T. J. Klopfenstein*, B. L. Nuttelman*, W. A. Griffin*, J. R. Benton*, and M. J. Rincker†

**Department of Animal Science, University of Nebraska-Lincoln, 68583*
†DPI Global, Porterville, CA 93257

Abstract

Two experiments using 96 steers each were conducted to evaluate the impact of feeding Micro-Aid in diets containing wet distillers grains plus solubles (WDGS) on cattle performance and nutrient mass balance in open feedlot pens. Micro-Aid (DPI Global, Porterville, CA) is a feed ingredient from an all natural plant extract, which contains saponins that have natural detergent and surfactant properties. Ninety-six Calves (301 ±11 kg BW) were fed for 180 days from November to May (winter) and yearlings (n=96, 321 ± 9 kg BW) were fed 160 days from May to November (summer). Dietary treatments consisted of a basal diet which contained 35% WDGS, 55% corn included at a ratio of 1:1 dry-rolled corn and high-moisture corn, 5% wheat straw, and 5% supplement (CON), Micro-Aid included at an inclusion of 1.0 g per steer daily (TRT). There was no difference ($P \geq 0.09$) in carcass and performance characteristics between treatments. Nitrogen intake, retention, and excretion were not different ($P \geq 0.66$) among treatments in either experiment. During the winter experiment, the amount of OM and N removed in the manure was greater for TRT compared with CON ($P \leq 0.05$). In the winter experiment, the amount of N lost via volatilization was reduced ($P = 0.05$) for the cattle fed TRT compared with CON but was not different ($P = 0.69$) during the summer. Phosphorus intake, retention, and excretion were not different

($P \geq 0.65$) among treatments in both experiments. Manure P was greater ($P = 0.02$) for cattle fed TRT than CON in the winter, but was not different ($P = 0.82$) in the summer. Nitrogen to phosphorus ratios were not different ($P \geq 0.67$) in both experiments.

Keywords: distillers grains, mass balance, saponins

Introduction

Wet distillers grains plus solubles (WDGS) are the primary grain byproduct used in the Midwest in finishing diets with inclusion levels from 5 to 50% of diet DM (Vander Pol et al., 2006). When WDGS is fed as an energy source, protein and P are fed in excess of requirements due to a three-fold increase compared to corn (Stock, 2000). Once the nutrient requirements are met by the animal, the excess is excreted on the pen surface. Luebbe et al. (2009) observed that feeding WDGS in the diet at 30% (DM), resulted in a greater amount of OM in the manure, increased manure N, and also increased N losses. Excess nutrient on the pen surface may create challenges for air and water quality. Nitrogen has the potential of being volatilized from the pen surface, and both nutrients can contribute to contamination of surface and ground water by N and P (Vasconcelos, 2007).

Options have been explored to reduce N losses from the pen surface. Increasing the carbon to nitrogen (C:N) of manure has successfully at decreasing N losses (Bierman et al., 1999; Erickson and Klopfenstein, 2001; Adams et al., 2004). Carbon may be directly applied to the pen surface or indirectly by manipulating the diet. Feeding less digestible feedstuffs, shifts dietary fiber digestion to the hindgut increasing the amount of OM excreted (Bierman et al., 1999). However, reduced animal performance may result when feeding a less digestible energy source (Adams et al., 2004; Sayer et al., 2005).

Increasing the frequency of pen cleaning reduces the amount of time manure is exposed to the atmosphere, reducing N losses (Adams et al., 2004; Wilson et al., 2004).

Micro-Aid (DPI Global, Porterville, CA) is a feed ingredient derived from the *Yucca schidegera*. Yucca extract contains saponins which have surfactant properties (Cheeke, 2000; Wallace et al., 2004). Saponins have the potential to form irreversible complexes with the cholesterol of protozoal cell membranes, which may lead to cell lysis and death (Cheeke, 2000). Reduced ciliate protozoa in the rumen increases microbial yield, and can reduce ruminal ammonia concentrations and methane emissions (Cheeke, 2000; Wallace et al., 2004). Saponins in the diet have shown mixed results on performance and carcass characteristics, with the majority showing no impact (Dorn, 1985; Mader and Brumm, 1987; Nichols et al., 2011).

By-products used in feedlot diets increase N losses, however methods have been studied to reduce N losses from the feedlot pen surface. The objective of this study was to determine the effect of feeding Micro-Aid in diets that contained WDGS on performance and carcass characteristics and nutrient mass balance.

Materials and Methods

Cattle Performance

The University of Nebraska's Institutional Animal Care and Use Committee approved all procedures and guidelines involving animals. Two experiments were conducted using 96 steers each, calves (301 ±11 kg BW) were fed for 180 days from November to May (winter) and yearlings (321 ± 9 kg BW) were fed 160 days from May to November (summer). Steers were received at the University of Nebraska Agricultural Development and Research Center (near Mead, NE) during the fall of 2009. Steers were weighed, vaccinated for *pasturella*, PI[3], BRSV, *haemophislus somnus*, and internal and external parasites (Bovishield Gold 5, Somubac, and Dectomax; Pfizer Animal Health, New York, NY), treated with Micotil (Elanco Animal Health, Greenfield, IN), and weaned on smooth bromegrass pasture. Yearlings used in the summer experiment were received as calves and backgrounded on cornstalks. Steers were weighed initially on 2 consecutive days after being limit-fed 2% of BW (6.2 kg/steer/d (winter) and 6.4 kg/steer/d (summer); DM basis) for 5 d to minimize gut fill. The limit-fed diet was 25% grass hay, 25% alfalfa hay, and 50% wet corn gluten feed (DM basis). Steers were blocked by BW, stratified within block and assigned randomly to pen (8 steers/pen). Dietary treatments (Table 1) consisted of 35% WDGS, 55% corn fed at a ratio of 1:1 dry-rolled corn and high-moisture corn, 5% straw, and 5% supplement (CON), with Micro-Aid (DPI Global, Porterville, CA) added in the treatment supplement at an inclusion of 1g per steer daily (TRT). During a 21-d adaptation period, alfalfa hay was replaced with a DRC:HMC blend at 35%, 25%, 15%, and 7.5%, for 3, 4, 7 and 7 days, respectively. The supplement was formulated to provide a Ca:P of 1.4:1 and 33 mg/kg monensin (*Elanco Animal Health, Indianapolis, IN*). Tylosin was not included in the diet.

Steers in the winter experiment were implanted on day 1 with Revalor-IS (Merck, Whitehouse Station, NJ) followed by Revelor-S (Merck) on day 80. Steers in the summer experiment were implanted with Revalor-S on day 36. Steers were slaughtered on day 180 (winter) and day 160 (summer) at a commercial abattoir (Greater Omaha, Omaha, NE). Hot carcass weight and liver scores were recorded on day of slaughter. Fat thickness, and LM area were measured after a 48-hour chill and USDA called marbling score was recorded. Final BW, ADG, and G:F were calculated based on HCW adjusted to a common dressing percentage of 63. Yield grade was calculated as follows: 2.50 + (2.5 * 12th rib fat thickness) – (.32 * LM strs) + (.2 * KPH (2.5)) + (.0038 * HCW) developed by Boggs and Merkel (1993).

Nutrient Balance

Mass balance for N and P was conducted similar to experiments previously outlined (Erickson and Klopfenstein, 2001; Luebbe et al., 2009) in 12 feedlot pens. Dietary treatments were fed in the same pens for both experiments. Stocking densities were 29.6 m^2/steer for each experiment. Weekly ingredient and feed refusals were collected to determine DM and nutrient intake. Samples were dried in a 60˚ forced air dry oven (AOAC, 1999; method 4.2.03) for 48 h to determine DM. Feed ingredient samples were collected weekly and composited by month. All samples were ground through a Wiley Mill (1-mm screen) and ashed at 600˚C for 6 h (AOAC, 1999; method 4.1.10) to determine OM.

Nutrient mass balance experiments were conducted using 12 open feedlot pens with retention ponds to collect runoff. When rainfall occurred, runoff collected in the retention ponds was drained and quantified using an air bubble flow meter (ISCO, Lincoln, NE.). Runoff was composited by pond using a weighted average and analyzed for DM, P, and N by a commercial laboratory (Ward Laboratories, Kearney, NE) with the following procedures: DM (dried in 105 degree oven; Helrich, 1990; AOAC Inc., Method 935.28), N (Leco FP-2000 Nitrogen Combustion Analyzer; Miller et al., 1997), and P (Bissel, 1997). Runoff N and P was calculated using nutrient concentration in the runoff multiplied by the volume of water collected.

Before placing cattle in pens, 16 soil core samples (15.2 cm depth) were taken from each pen in both experiments. After manure was removed, additional soil core samples (n=16, 15.2 cm depth) were taken from each pen to assess differences in pen cleaning and removal of soil. Upon cattle removal, manure was piled on a cement apron and sampled (n=30) for nutrient analysis while being loaded. Manure was weighed as-is and used to calculate DM, OM, N, P, and micro minerals (Ca, Cu, Fe, K, Mg, Mn, Na, S, and Zn) removed. Once collected, all samples were frozen at -4˚C until analysis. To avoid N losses during the drying process, a portion of manure samples (n=20/pen) were freeze-dried using a Virtis Freezemobile model 25 SL (Virtis, Gardiner, NY). The remainder of the manure samples were oven-dried for 48 h at 60˚C (AOAC, 1999; method 4.2.03) to determine DM content. Freeze-dried samples were ground through a Wiley Mill at a 1-mm screen size and composited by pen. Manure and core samples were composited by pen and analyzed for nutrients and minerals by the following methods: N (Leco FP 528, Leco Corp., St. Joseph, MO), P (Mehlich III Method; Mehlich, 1984), S (Lachat FIA using Lachat FIA analyzer; Lachat Instruments, Milwaukee, WI), Zn, Fe, Mn, Cu (DTPA extraction using atomic absorption spectrophotometer; Soil and Plant Analysis Council Inc. 1999; Lindsay and Norvell, 1978), K, Na, Mg (analyzed using an atomic emission spectrophotomether; Brown and Warncke, 1998).

Total N for feed ingredients and feed refusals was analyzed using a combustion method N analyzer (Leco FP 528, Leco Corp., St. Joseph, MO). Feed ingredients were analyzed for P and micro-minerals by Ward Laboratories (Kearney, NE). The following procedures were used: P (Mehlich III Method; Mehlich, 1984), Zn, Fe, Mn, Cu (atomic absorption spectrophotometer; Isaac and Kerber, 1971), Ca, Mg (atomic absorption spectrophotometer; Padmore, 1990), K, Na (atomic absorption spectrophotometer; AOAC 1990, Method 968.08).

Amount of manure N, P, OM, and micro minerals was calculated by multiplying manure nutrient concentration (kg of nutrient/kg of DM) by kg of manure removed (DM basis) from the pen surface. Runoff N and P were calculated using nutrient concentration in the runoff multiplied by the volume of water collected. Nitrogen and P intake were calculated using analyzed N and P content of individual dietary ingredients multiplied by DMI and ingredient inclusion level and corrected for N and P content of feed refusals. Retained N and P were calculated using the energy, protein, and P retention equations (NRC, 1996) for individual animals and averaged by pen. Nutrient excretion was determined by subtracting nutrient retention from intake (ASABE, 2005). Total N lost (kg/steer) was calculated by subtracting manure N (corrected for soil N content) and runoff N from excreted N. Percentage of N lost was calculated as N lost divided by N excretion.

Cattle performance, carcass characteristics, and mass balance data were analyzed as a randomized complete block design in Exp 1. and completely randomized design in Exp 2. using the MIXED procedure of SAS (SAS Inst. Inc. Cary, NC). 1. Incidence of liver abscesses was analyzed using the GLIMMIX procedure of SAS. Model effect was treatment and block was a random effect in Exp.

Results and Discussion

Cattle Performance

The addition of Micro-Aid to the diet had no effect ($P \geq 0.09$) on performance or carcass characteristics in either experiment as presented in Tables 3 and 4. Dry matter intake, ADG, and G:F were not different among treatments ($P > 0.65$) in both experiments (Tables 3 and 4). Carcass characteristics were not influenced ($P > 0.06$) by the inclusion of Micro-Aid in the diet in either experiment.

It is thought that Micro-Aid alters the rumen environment which may in turn enhance cattle performance. By forming complexes with cholesterol in the protozoal cell membrane, ciliate protozoa are reduced (Cheeke, 2000; Wallace, 2004; Hristov, 1999). These authors found a reduction in ciliate protozoa in rumen fluid when yucca schidergia is fed in the diet. Since protozoa prey on rumen bacteria, species that produce propionate such as *Selenomonas ruminantium* fill the niche. Propionate is the only VFA which makes a net contribution to glucose synthesis (Van Soest, 1982). Increased propionate production has the potential to enhance animal performance, by increasing efficiency. However, in the current study no differences were found in animal performance. Similar performance and carcass characteristics was also observed by Nichols et al. (2011), in which no difference was seen in performance characteristics when a yucca saponin (Ruma-Just, Nova Microbial Technologies) was included in a SFC (72%) and WDGS (11%) diet at 1 g/hd/day. Dorn et al. (1985) observed no differences in performance when saponins were fed in a 82% concentrate diet.

Tylosin (Tylan) was not included in either diet to determine if Micro-Aid had an effect on the number of liver abscesses. Nagaraja and Chengappa (1998) reported the incidence of liver abscesses in feedlots averages from 12-32%. The addition of Tylosin to the diet reduces incidence of abscess by 40 to 70% (Nagaraja and Chengappa, 1998). With the exception of the cattle fed Micro-Aid during the summer experiment, the incidence of liver abscesses fell within this range, however, no differences ($P \geq 0.12$) were found in the number of liver abscesses whether cattle were fed Micro-Aid or not in the diet. During the winter experiment, there was no difference ($P = 0.75$) in the incidence of liver abscesses with 16.7% for the CON cattle and 19.1% for TRT steers. There was no significant difference ($P = 0.12$) during the summer as well. However, numerically cattle fed Micro-Aid had a greater percentage of liver abscesses (38.3%) compared to the CON group (23.4%).

Nitrogen Mass Balance

Nitrogen intakes were similar between groups during the winter ($P > 0.65$; Table 5) with 46.5 kg for the CON group and 46.0 kg for the TRT. Since there was no difference in ADG and carcass composition, N retention was similar ($P > 0.75$). Consequently, N excretion was not different between the CON and TRT cattle (41.0 kg vs. 40.5 kg). Rainfall during the feeding period is represented in Table 2. Nitrogen runoff was not different ($P > 0.90$) between treatments averaging 2.57% of total N excretion. These results are similar to what was observed by Adams et al. (2004) and Luebbe et al. (2009) who observed low amounts of N (0.8 – 2.0% of total N excreted) in the runoff. Total N in manure was greater ($P = 0.03$) for cattle fed the TRT diet (25.6 kg) compared to the CON group (18.5 kg). Dry matter removed was numerically higher for TRT cattle but not significantly different ($P = 0.09$) than the CON diet. However, OM removed was greater ($P = 0.02$) for TRT cattle (534 kg) than the CON cattle (370 kg).

Although these values are larger, they fall within values Kissinger et al. (2006) reported from 18 experiments over a 10-year period. The amount of N lost via volatilization was greater (P = 0.05) for the CON cattle (21.4 kg) than the TRT (13.9 kg). When expressed as a percent of N loss compared to total N excretion, the CON group was greater (P = 0.04) than the TRT diet at 52.2 and 34.0%, respectively.

Nitrogen intake, retention, and excretion were similar (P > 0.70) among treatments (Table 6) during the summer. When expressed as a percent of total N excreted, N in runoff accounted for 4.07% for the CON and 2.82% for the TRT group, which is less than 5% of total N excreted, also reported in previous mass balance studies by Adams et al.(2004), Kissinger et al. (2006), and Luebbe et al. (2009) at 3.0, 2.7, and 4.0%, respectively. Manure N was not different (P = 0.78) between the CON and TRT cattle at 8.03 and 7.66 kg, respectively. The amount of DM and OM removed during pen cleaning was not different (P ≥ 0.64) during the summer experiment. The amount of DM removed for cattle on the CON diet was 482 kg and 125 kg of OM compared to the TRT cattle with 476 kg of DM and 104 kg of OM removed at pen cleaning. The current data support Kissinger's summary (2006) that DM and OM removed was twice as much in the winter compared to the summer months. This somewhat contradicts research by Luebbe et al. (2009) in which WDGS in the diet at 30% (DM) resulted in more DM removed during the summer than the winter feeding period, but agrees with their findings in which OM removed was greater (1.5x) in the winter than in the summer experiment. These differences may be a result of soil removed with manure during pen cleaning. The inclusion of Micro-Aid in the diet had no effect (P = 0.69) on N lost, and as a result, no differences (P = 0.60) were found in the amount of N lost expressed as a percent of N excreted, with 71.9% for CON cattle and 73.8% for TRT.

Phosphorus Mass Balance

There was no difference (P = 0.65; Table 7) in P intake in the winter. No differences in cattle performance during the winter experiment, led to similar (P = 0.81) P retention between the two groups. As a result, there was no difference (P = 0.67) in the amount of P excreted as well, averaging 7.53 kg, respectively. In the winter experiment, manure P was greater (P = 0.02) for cattle fed the TRT diet (14.3 kg) than the CON cattle (10.2 kg). These values are more (2x and 1.5x) than the amount of P excreted for the TRT and CON steers, suggesting removal of manure mixed with soil from before the experiment. Treatment did not influence P in runoff (P = 0.69) in the winter, representing 6.64% of total P excreted. Nitrogen to phosphorus ratio was not different (P = 0.67) for the CON and TRT group, at 1.75 and 1.72, respectively.

In the summer experiment, P intake was similar (7.89 kg; P = 0.79) between the two groups (Table 8). Phosphorus retention was similar (P = 0.78) due to comparable performance characteristics. Accordingly, there were no differences (P = 0.82) in P excretion for the CON and TRT cattle, with an average value of 6.58 kg in the summer. Manure P was similar (P = 0.82) between the CON and TRT cattle, with 4.15 and 3.79 kg, respectively. Hence, 52.8% of total P excreted was accounted for in manure correcting for soil, with an additional 7.76% in the runoff. There was no difference (P = 0.68) in the N:P ratio (1.90 and 2.01 for CON and TRT, respectively).

Since P is not volatilized, it is subjected to less biological transformation compared with N, and therefore, P removal in manure should be similar to P excretion

(Vasconcelos et al., 2007). In the winter, manure P exceeded the amount of P excreted by 191 and 135% for the Micro-Aid and CON diet, respectively. These values that exceed the amount of P excreted are supported by the idea that during the winter feeding period conditions are wetter. Consequently, higher soil inclusion with manure solids may result in manure P exceeding P excretion when pens are cleaned (Kissinger et al., 2006). On the contrary, 39.4% of the P excreted was not accounted for in the summer experiment. These lower P recoveries are typical in the summer, as reported by Luebbe et al. (2009), and are due to drier conditions when pens are cleaned in the fall. Compared to wet conditions during spring cleaning, soil is not as thoroughly mixed with manure.

Minerals

Mineral intake was not different ($P > 0.05$) between groups, with the exception of Ca, Mn, and Cu (Table 9) for the winter experiment. Calcium, Mn, and Cu intake were different between groups due to diet composition when Micro-Aid is added to the diet (Table 1). Calcium intake was lower ($P = 0.03$) for TRT cattle (12.8 kg) compared to CON (14.9 kg). Manganese intake was also lower ($P < 0.01$) for TRT cattle than CON, with 566 and 601 g, respectively. The same was observed ($P < 0.01$) for Cu with 272 g for TRT and 312 g for CON groups. Mineral concentrations in manure were similar ($P > 0.05$) between the CON and TRT cattle, with the exception of manure Mn concentration (386 and 423 ppm for CON and TRT, respectively; $P = 0.03$) for the winter experiment (Table 9). However, when expressed as kg or g/steer removed in manure, mineral amounts tended to be numerically greater and some (Ca, K, Mg, and Zn) significantly greater ($P < 0.05$) for TRT cattle. The greater amount of minerals removed for TRT cattle are due to more DM removal per animal fed the TRT diet (3565 kg) compared to the CON cattle (2774 kg).

During the summer experiment, mineral intake was similar ($P > 0.05$), with the exception of Ca, Mn, and Cu (Table 10) due to diet composition (Table 1). Treatment cattle had lower ($P \leq 0.01$) Ca, Mn, and Cu intakes (10.8 kg, 501 g, and 239 g, respectively) compared to the CON cattle (12.7 kg, 529 g, and 273 g). All manure mineral concentrations were not different ($P > 0.05$) between treatments (Table 10). Since DM removed was similar between treatments, no difference ($P > 0.05$) was calculated in the amount of these nutrients removed.

Manure Composition

When comparing manure composition of the experiments evaluated to 2005 ASABE standards, cattle in the current study consumed 1605 g CP/d (winter) and 1516 g CP/d (summer) compared to the standard diet of cattle consuming 1200 g CP/d. Although N intake was greater in the current experiments, N removed in the manure was less than the ASABE standard of 25 kg N/animal, with the exception of cattle fed the TRT diet in the winter (27.2 kg/steer). The ASABE reports that manure composition for a 554 kg steer fed 25 g/d of P was 3.3 kg. Steers in the current experiments were fed 49 g P/d. There was no difference between the CON and TRT groups for the amount of manure P in the summer at 3.97 kg/steer which is relatively close to the standard of 3.3 kg. However, cattle fed in the winter greatly exceed this standard, with 10.2 and 14.3 kg for the CON and TRT steers, respectively. Phosphorus recovery is highly variable, but this difference may be partially due to cattle spending more time on feed and being fed about twice the amount of P daily. However, as discussed previously, this may be largely influenced by seasonal variation.

The addition of Micro-Aid in the diet had no effect on performance and carcass characteristics. In terms of mass balance, positive results were observed during the winter feeding period, but not in the corresponding summer experiment. When fed in the winter, the amount of DM and OM removed was greater for cattle fed Micro-Aid. Additionally, N retained in the manure was greater for cattle fed Micro-Aid, as well as the amount of N lost via volatilization was reduced. However, when fed during the summer, Micro-Aid in the diet showed no difference in nitrogen or phosphorus mass balance. Consequently, Micro-Aid has potential to reduce N losses when fed at 1g/hd/d to cattle fed during the winter without effecting performance and carcass composition.

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Table 1. Composition of diets (% of diet DM) fed in both winter and summer experiments

Ingredient	CON[1]	TRT[2]
Wet distillers grains	35.0	35.0
High moisture corn	27.5	27.5
Dry rolled corn	27.5	27.5
Wheat straw	5.0	5.0
Dry Supplement[3]		
Fine ground corn	2.77	2.76
Limestone	1.72	1.72
Salt	0.30	0.30
Tallow	0.13	0.13
Trace mineral premix[4]	0.05	0.05
Rumensin-80 premix[5]	0.019	0.019
Vitamin premix[6]	0.015	0.015
Micro-Aid[7]	-	0.011
Nutrient Analysis		
Crude Protein	16.4	16.4
Calcium	0.855	0.733
Phosphorus	0.509	0.509
Potassium	0.799	0.799
Sulfur	0.368	0.362
Magnesium	0.208	0.207
Zinc	0.006	0.006
Manganese	0.003	0.003
Copper	0.002	0.002
Sodium	0.198	0.201

[1]CON = Control
[2]TRT = Treatment (cattle fed 1g/hd/d Micro-Aid)
[3]Formulated to be fed at 5% of diet DM.
[4]Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, and 0.05% Co.
[5]Premix contained 176 g/kg monensin
[6]Premix contained 30,000 IU vitamin A, 6,000 IU vitamin D, 7.5 IU vitamin E per g.
[7]Micro-Aid added to treatment supplement at 1g/hd/d

Table 2. Rainfall during the feeding period (mm)[1].

Month	Winter[2]	Summer[3]
January	13.2	
February	0.0	
March	0.0	
April	32.3	
May	9.1	5.1
June		106.4
July		172.0
August		63.2
September		86.4
October		5.8
November	0.5	48.3
December	0.3	
Total Precipitation	55.4	487.2

[1]Weather for Ithaca, NE
Available at http://www.wunderground.com Accessed 29 October 2011
[2]Cattle were fed from November to May
[3]Cattle were fed from May to November

Table 3. Growth performance and carcass characteristics for steers fed Micro-Aid during the winter[1].

Variable	CON[2]	TRT[3]	SEM	P-value
Performance				
Initial BW, kg	302	302	0	0.89
Final BW, kg[4]	574	569	6	0.58
DMI, kg/d	9.61	9.48	0.2	0.65
ADG, kg	1.51	1.49	0.07	0.66
G:F	0.157	0.157	0.003	0.83
Carcass Characteristics				
HCW, kg	362	359	4	0.56
Marbling score[5]	547	560	13	0.48
12th rib fat, cm	1.45	1.54	0.6	0.93
LM area, cm^2	80.6	78.1	0.03	0.09
Calculated YG[6]	3.40	3.40	0.07	1.00
Liver Abscesses, %	16.7	19.1	-	0.75

[1]Cattle were fed 180 d from November to May
[2]CON = Control
[3]TRT = Treatment (cattle fed 1g/hd/d Micro-Aid)
[4]Final weight calculated as hot carcass weight divided by 0.63.
[5]500 = Small 0, 600 = Modest 0.
[6]YG calculation = 2.50 + (2.5 * 12th rib fat thickness) – (.32 * LM area) + (.2 * KPH (2.5)) + (.0038 * HCW)

Table 4. Growth performance and carcass characteristics for steers fed Micro-Aid during the summer[1].

Variable	CON[2]	TRT[3]	SEM	P-value
Performance				
Initial BW, kg	321	321	1	0.93
Final BW, kg[4]	594	590	5	0.67
DMI, kg/d	9.43	9.39	0.13	0.76
ADG, kg	1.70	1.69	0.04	0.71
G:F	0.180	0.180	0.003	0.80
Carcass Characteristics				
HCW, kg	374	372	3	0.67
Marbling score[5]	546	537	14.4	0.66
12th rib fat, cm	1.40	1.30	0.05	0.27
LM area, cm^2	83.9	84.5	0.5	0.67
Calculated YG[6]	3.13	3.01	0.22	0.72
Liver Abscesses, %	23.4	38.3	-	0.12

[1]Cattle were fed for 160 d from May to November
[2]CON = Control
[3]TRT = Treatment (cattle fed 1g/hd/d Micro-Aid)
[4]Final weight calculated as hot carcass weight divided by 0.63.
[5]500 = Small 0, 600 = Modest 0.
[6]YG calculation = 2.50 + (2.5 * 12th rib fat thickness) – (.32 * LM area) + (.2 * KPH (2.5)) + (.0038 * HCW)

Table 5. Effect of Micro-Aid on N mass balance during winter[1].

Variable	CON[2]	TRT[3]	SEM	P-value
N intake, kg	46.5	46.0	0.7	0.66
N retention, kg[4]	5.49	5.44	0.14	0.76
N excretion, kg[5]	41.0	40.5	0.7	0.68
Manure N, kg[6]	18.5	25.6	2.0	0.03
N Run-off, kg	1.07	1.02	0.32	0.92
N Lost, kg	21.4	13.9	2.3	0.05
N Loss, %[7]	52.2	34.0	5.4	0.04
DM removed, kg	2771	3561	293	0.09
OM removed, kg	370	534	43	0.02

[1]Values are expressed as kg/steer over entire feeding period (180 DOF).
[2]CON = Control
[3]TRT = Treatment (cattle fed 1g/hd/d Micro-Aid)
[4]Calculated using the NRC net protein and net energy equations.
[5]Calculated as N intake – N retention.
[6]Manure N with correction for soil N
[7]Calculated as N lost divided by N excretion

Table 6. Effect of Micro-Aid on N mass balance during summer[1].

Variable	CON[2]	TRT[3]	SEM	P-value
N intake, kg	38.8	38.6	0.5	0.79
N retention, kg[4]	5.43	5.38	0.10	0.73
N excretion, kg[5]	33.4	33.2	0.5	0.83
Manure N, kg[6]	8.00	7.66	0.88	0.78
N Run-off, kg	1.38	1.07	0.16	0.20
N Lost, kg	24.0	24.5	0.9	0.69
N Loss, %[7]	71.9	73.8	2.5	0.60
DM removed, kg	482	476	96	0.97
OM removed, kg	125	104	31	0.64

[1]Values are expressed as kg/steer over entire feeding period (160 DOF).
[2]CON = Control
[3]TRT = Treatment (cattle fed 1g/hd/d Micro-Aid)
[4]Calculated using the NRC net protein and net energy equations.
[5]Calculated as N intake – N retention.
[6]Manure N with correction for soil N
[7]Calculated as N lost divided by N excretion

Table 7. Effect of Micro-Aid on P mass balance during winter[1].

Variable	CON[2]	TRT[3]	SEM	P-value
P intake, kg	8.89	8.80	0.14	0.65
P retention, kg[4]	1.34	1.33	0.03	0.81
P excretion, kg[5]	7.55	7.47	0.13	0.67
Manure P, kg[6]	10.2	14.3	1.0	0.02
Run-off P, kg	0.46	0.54	0.10	0.69
N:P ratio[7]	1.75	1.72	0.32	0.67

[1]Values are expressed as kg/steer over entire feeding period (180 DOF).
[2]CON = Control
[3]TRT = Treatment (cattle fed 1g/hd/d Micro-Aid)
[4]Calculated using the NRC net protein and net energy equations.
[5]Calculated as P intake – P retention.
[6]Manure P with correction for soil P
[7]Nitrogen to Phosphorus ratio, DM basis

Table 8. Effect of Micro-Aid on P mass balance during summer[1].

Variable	CON[2]	TRT[3]	SEM	P-value
P intake, kg	7.91	7.87	0.10	0.79
P retention, kg[4]	1.32	1.31	0.03	0.78
P excretion, kg[5]	6.59	6.56	0.09	0.82
Manure P, kg[6]	4.15	3.79	0.55	0.82
Run-off P, kg	0.56	0.47	0.07	0.48
N:P ratio[7]	1.98	2.06	0.13	0.68

[1]Values are expressed as kg/steer over entire feeding period (160 DOF).
[2]CON = Control
[3]TRT = Treatment (cattle fed 1g/hd/d Micro-Aid)
[4]Calculated using the NRC net protein and net energy equations.
[5]Calculated as P intake – P retention.
[6]Manure P with correction for soil P
[7]Nitrogen to Phosphorus ratio, DM basis

Table 9. Micro mineral intake and manure mineral concentration and amount removed in the winter[1]

Variable	CON[2]	TRT[3]	SEM	P-value
Sulfur Intake, kg	6.13	5.92	0.10	0.19
Manure Sulfur, %	0.20	0.24	0.02	0.15
Manure Sulfur, kg[4]	4.95	7.37	0.80	0.06
Calcium Intake, kg	14.9	12.8	0.22	<0.01
Manure Calcium, %	0.96	1.03	0.05	0.30
Manure Calcium, kg[4]	26.0	36.2	2.2	0.01
Potassium Intake, kg	14.4	14.4	0.2	0.80
Manure Potassium, %	0.68	0.75	0.03	0.19
Manure Potassium, kg[4]	18.0	26.2	2.6	0.05
Magnesium Intake, kg	3.60	3.56	0.06	0.61
Manure Magnesium, %	0.40	0.43	0.01	0.09
Manure Magnesium, kg[4]	9.97	14.4	1.38	0.05
Sodium Intake, kg	3.42	3.43	0.05	0.85
Manure Sodium, %	0.09	0.10	0.01	0.10
Manure Sodium, kg[4]	2.24	3.30	0.40	0.10
Zinc Intake, g	108	110	2.0	0.56
Manure Zinc, ppm	93	96	0.4	0.68
Manure Zinc, g[5]	250	336	24.0	0.03
Iron Intake, kg	0.179	0.182	0.003	0.57
Manure Iron, %	1.06	1.11	0.04	0.40
Manure Iron, kg[4]	29.2	39.6	3.7	0.07
Mangenese Intake, kg	6.01	5.66	0.9	0.03
Manure Mangenese, ppm	386	423	10.0	0.03
Manure Mangenese, kg[4]	1.14	1.57	0.14	0.06
Copper Intake, g	312	272	0.5	<0.01
Manure Copper, ppm	22.0	23.0	1.0	0.32
Manure Copper, g[5]	107	94	10.0	0.40

[1]Values are expressed as kg/steer over entire feeding period (180 DOF).
[2]CON = Control
[3]TRT = Treatment (cattle fed 1g/hd/d Micro-Aid)
[4]Manure micro minerals (kg/steer) with correction for soil micro minerals
[5]Manure micro minerals (g/steer) with correction for soil micro minerals

Table 10. Micro mineral intake and manure mineral concentration and amount removed in the summer[1]

Variable	CON[2]	TRT[3]	SEM	P-value
Sulfur Intake, kg	6.13	5.92	0.10	0.19
Manure Sulfur, %	0.23	0.22	0.01	0.69
Manure Sulfur, kg[4]	4.95	7.37	0.80	0.06
Calcium Intake, kg	12.7	10.8	0.14	<0.01
Manure Calcium, %	3.65	4.78	1.30	0.55
Manure Calcium, kg[4]	5.04	3.49	1.58	0.51
Potassium Intake, kg	12.9	12.8	0.16	0.83
Manure Potassium, %	0.65	0.64	0.02	0.74
Manure Potassium, kg[4]	5.04	3.45	1.58	0.50
Magnesium Intake, kg	3.26	3.24	0.04	0.70
Manure Magnesium, %	0.43	0.45	0.01	0.32
Manure Magnesium, kg[4]	5.04	3.02	1.63	0.41
Sodium Intake, kg	3.18	3.21	0.04	0.60
Manure Sodium, %	0.10	0.09	0.01	0.62
Manure Sodium, kg[4]	5.04	2.95	1.64	0.39
Zinc Intake, kg	.0952	0.0973	0.001	0.26
Manure Zinc, ppm	127	127	4.0	0.95
Manure Zinc, kg[4]	5.04	2.88	1.66	0.38
Iron Intake,kg	0.168	0.171	2.0	0.37
Manure Iron, %	1.15	1.19	0.06	0.66
Manure Iron, kg[4]	5.04	3.59	1.58	0.53
Mangenese Intake, g	52.9	50.1	0.70	0.01
Manure Mangenese, ppm	445	465	2.0	0.57
Manure Mangenese, g[5]	433	409	94.0	0.86
Copper Intake, g	27.3	23.9	0.3	<0.01
Manure Copper, ppm	24.0	28.0	2.0	0.10
Manure Copper, g[5]	165	115	39.0	0.38

[1]Values are expressed as kg/steer over entire feeding period (160 DOF).
[2]CON = Control
[3]TRT = Treatment (cattle fed 1g/hd/d Micro-Aid)
[4]Manure micro minerals (kg/steer) with correction for soil micro minerals
[5]Manure micro minerals (g/steer) with correction for soil micro minerals

CHAPTER III

Replacement of forage with byproducts and crop residue to cows grazing smooth bromegrass pasture.

A. J. Doerr, T. J. Klopfenstein, G. E. Erickson, K. M. Rolfe, B. L. Nuttelman, C. J. Schneider, W. A. Griffin, D. Burken, and W. H. Schacht

Abstract

Two studies were conducted to determine the effect of supplementing byproduct and crop residue blends to cattle grazing smooth bromegrass pasture on forage replacement. Cattle grazed at 1) the recommended stocking rate (7.56 AUM/ha in 2010 and 9.46 AUM/ha in 2011) with no supplementation (CON) or 2) double the recommended stocking rate (15.1 AUM/ha in 2010 and 18.9 AUM/ha in 2011) with supplementation (SUP). In experiment 1 (2010), nonpregnant, nonlactating cows (n=16, initial BW=577 ± 80 kg) grazed smooth bromegrass pasture from mid April to mid September (138 d). Supplemented cows were fed a 35% Synergy (ADM, Columbus, NE) and 65% wheat straw mixture daily. An ensiled mixture (46.6% DM) was fed from late April to mid-August and a fresh mixture (30.7% DM; mixed at feeding time from mid-August to mid-September. There were no performance or pasture forage quality differences observed ($P \geq 0.20$). Supplemented cows consumed 5.46 kg of supplement over the entire grazing season, replacing 40% of grazed forage intake. In experiment 2 (2011), cows with spring born calves at side (n=16, initial pair BW=675 ± 63 kg) grazed from early May to mid September (139 d). Supplemented pairs were fed a 30% MDGS and 70% cornstalk blend mixed fresh daily at time of feeding. Performance was not different ($P \geq 0.06$) between CON and SUP pairs. No differences ($P \geq 0.39$) were found in forage quality between paddocks grazed by the groups. Supplemented cattle consumed 13.6 kg of the mix, replacing 36.3% of forage intake. Supplementing by-

product and crop residue mixtures can replace forage intake of cattle grazing smooth bromegrass pasture.

Key words: beef cattle, byproducts, smooth bromegrass

Introduction

There are at least two reasons why supplemental feed would be needed for cattle grazing pasture. During times of drought, grass production is reduced and an option is to supplement. Additionally, producers may want to increase carrying capacity without purchasing or leasing more grass. In these cases there are two basic strategies to supplement feed. The first is to drylot cattle and the second option is to supplement cattle on pasture and to extend the grazing season.

Feeding byproduct and low quality forage supplement mixes has proven to be a successful strategy to replace forage intake of cattle grazing native range (Nuttelman et al., 2010; Villasanti et al., 2010). The objective of this study was to determine if this is also a successful strategy for cattle grazing smooth bromegrass pasture in eastern Nebraska. Crop residues on farms with cool-season grass pastures seem to be economical sources of fiber to feed during the summer to substitute smooth bromegrass consumption in Eastern Nebraska. Additionally, purchasing and (or) storing byproducts during the summer can be economical for producers. Most byproducts produced in Nebraska are consumed by finishing cattle in feedlots. However, feedlot cattle numbers tend to be lowest in the summer months, which make DGS more available to cow/calf producers. Mixing byproducts with crop residue may increase the palatability of the feed, and the bulk from the forage may provide a fill effect that potentially reduces grazed forage intake.

The objective of this study was to determine the effect of supplementing cattle grazing smooth bromegrass pasture a blend of byproduct and crop residue on grazed forage replacement. Cattle supplement consumption was observed. Observations were made concerning the ratio of by-product to low quality forage throughout the grazing season, as well as palatability issues related to ensiled or fresh mixtures.

Materials and Methods

All procedures were approved by the University of Nebraska's Institutional Animal Care and Use Committee. Cattle grazed smooth bromegrass pasture at the University of Nebraska-Lincoln Agricultural Research and Development Center near Mead, NE. Pastures were fertilized with 90 kg N/ha in the spring. The same paddocks were used for both experiments, with open cows grazing in 2010 and cow/calf pairs in 2011. Treatments consisted of paddocks stocked at: 1) the recommended stocking rate of 7.56 AUM/ha in 2010 and 9.46 AUM/ha in 2011 with no supplementation (CON); or 2) double the recommended stocking rate (15.1 in 2010 or 18.9 AUM/ha in 2011) with supplementation (SUP). According to Watson et al. (2010) stocking rates for smooth bromegrass pasture was calculated at 9.9 AUM/ha for grazing pastures fertilized with 90 kg N/ha in the spring. Based off these recommended stocking rates, CON pastures were stocked at 7.56 AUM/ha in experiment 1 and 9.46 AUM/ha for experiment 2. For the SUP pastures, double stocking rates were applied with 15.1 AUM/ha and 18.9 AUM/ha. At these assumed stocking rates, it was intended that supplement would replace 50% of grazed forage intake without causing deleterious effects to the pasture.

In experiment 1, nonpregnant, nonlactating cows (n=16) were assigned randomly to one of two treatments, with 4 cows/paddock and two replications. Cattle grazed for

138 days from April 28th to mid September 15th, 2010. Put and take cattle were added on June19th to maintain appropriate grazing pressure. Supplementation consisted of a 35% synergy (40% WCGF and 60% MDGS) and 65% wheat straw mixture (DM basis), which was fed in bunks daily. If refusals were present, orts were weighed and sampled to accurately estimate total consumption of mixes. An ensiled mixture (46.6% DM) was fed from late April to mid August (111 d) and fresh (30.7% DM; mixed at feeding time) from mid August to mid September (27 d). Cows (n=16) were limit fed a 50% synergy and 50% wheat straw diet at 2% of BW for five days prior to and at the conclusion of the grazing period to eliminate variation due to gut fill. Initial and final BW were an average of three consecutive day weights. It was expected that intake of grazed forage would be greatest early in the growing season and would decline as cool-season grass matured. Consequently, cows were supplemented at 0.56% of BW at trial initiation with increasing levels throughout the grazing period as forage quantity and quality decline in order to target 2.25% of BW at trial conclusion, with an average of 1.15% of BW over the entire grazing season. Therefore, supplement was intended to replace 50% of forage DM intake. Predicted forage DM intake was calculated using 2.12% of average BW over the grazing period (Meyer et al., 2010), and verified by the number of days to change BCS with the NRC (1996).

In Exp. 2 (2011), cow-calf pairs (n=16), non-gestating, lactating cows with spring born calves at side, were utilized and assigned randomly to treatment and the same paddocks grazed the previous year. Treatments consisted of paddocks stocked at: 1) 9.46 AUM/ha with no supplementation (CON); or 2) double the recommended stocking rate (18.9 AUM/ha) with supplementation (SUP). Pairs grazed the same smooth bromegrass pastures utilized in Exp. 1 from May 3rd to September 19th (139 days). Pairs grazed the same pasture for five days prior to trial initiation to try to eliminate variation due to differences in gut fill, before being assigned and moved to treatment paddocks. Initial and final BW was an average of two consecutive day weights. Supplement was mixed daily at time of feeding (FRESH). The mix was a 30:70 blend of MDGS and cornstalks (1 inch grind) and water was added to achieve 30% DM. To encourage cows to eat the mixture at the beginning of the trial, a 50:50 MDGS:cornstalks blend was fed with MDGS decreasing and cornstalks increasing by increments of 2 percentage units daily until a 30:70 mixture was reached. Predicted DM intake was calculated using 2.26% of average BW over the grazing period for each cow/calf pair (Meyer et al. 2010).

Diet Sample Collection and Analysis

Forage quality (CP, IVDMD, and NDF) was analyzed using ruminally fistulated steers. In Exp. 1, 2 steers grazed each paddock (replication) 5 times throughout the grazing season. However in Exp. 2, 3 steers grazed only one of the control and treatment replications at the beginning, middle, and end of the grazing season. Steers were fasted for 12 h and ruminally evacuated at 0800 each sampling day. Cattle were allowed to graze for 30 minutes. Diet samples were freeze-dried using a Virtis Freezemobile model 25 SL (Virtis, Gardiner, NY). Freeze-dried samples were ground through a Wiley Mill (Thomas Scientific, Swedesboro, NJ) at a 1-mm screen size. Crude protein was analyzed using a combustion method N analyzer (Leco FP 528, Leco Corp., St. Joseph, MO) and CP calculated by N x 6.25. Two ruminally fistulated cattle fed a basal diet of bromegrass (*Bromus inermis*) hay were utilized as donors to provide inoculant for IVDMD. The Tilley and Terry method (1963) modified by the addition of 1g/L of urea to McDougall's buffer (Weiss, 1994) was used to determine IVDMD. All IVDMD runs had 5 standard feed samples of varying quality and known in vivo DM digestibility included. The IVDMD were then regressed to their known digestibilities in order to develop regression equations for each run to calculate total tract DM digestibility (TTDMD; Geisert et al., 2006). The NDF content of diets was determined by the method of Goering and Van Soest (1970).

All data were analyzed using the MIXED procedures of SAS (SAS Inst., Inc., Cary, NC). Paddock was the experimental unit. Model effects included date and treatment. Orthogonal contrasts were used to detect linear and quadratic effects of forage quality by month. Differences were considered significant at P-values < 0.05.

Results and Discussion

Performance and Grazed Intake

There were no differences ($P \geq 0.02$) in forage quality between paddocks grazed by the CON and SUP cattle in either experiment (Table 2). For Exp. 1 (2010), IVDMD averaged 55.5%, CP was 17.4%, and NDF was 59.5%. In 2011 for Exp. 2, forage quality was 58.6% IVDMD, 18.9% CP, and 59.6% NDF. The IVDMD values from these experiments are similar to the IVDMD value of 56.8% reported by Watson (2010) for smooth bromegrass pasture. Crude protein values however were slightly higher with 17.4 and 18.9% for these experiments compared to that observed by others, 15.8% (Watson, 2010).

In both experiments, no significant differences ($P \geq 0.06$) in cattle performance were observed (Tables 5 and 6). Supplemented cattle achieved similar gains as the CON even when stocking rate was doubled for the supplemented pastures, but there was a trend for greater (P=0.06) calf final BW for the SUP group (Table 6). No differences in performance indicate that supplement replaced grazed forage intake. In a study conducted by Nuttelman et al. (2010) to evaluate the impact of feeding different ratios of WDGS and wheat straw mixtures to cow/calf pairs grazing native range, no performance differences were observed as well. Pairs grazed at the recommended stocking rate or at double the recommended rate and were supplemented either a 50:50, 40:60, or 30:70 ensiled WDGS and wheat straw blend. Average daily gain was not affected by supplementation or ratio of the blend (Nuttelman et al., 2010).

In Exp. 1, dry cows consumed 13.6 kg and 13.8 kg of forage for the CON and SUP cattle (respectively; Table 5) based off calculations of 2.12% of average BW (Meyer et al., 2010). Throughout the grazing period, SUP cows consumed 5.46 kg/hd/d of the synergy:straw supplement. Consequently, supplementing dry cows a 30:70 synergy:straw mixture replaced 40% of grazed forage. Nuttelman et al. (2010) observed a slightly higher replacement value when an ensiled 30% WDGS and 70% wheat straw supplement was fed to pairs grazing native range. In this experiment, the 70:30 wheat straw:WDGS blend nearly replaced grazed forage intake on a 1:1 basis (Nuttelman et al., 2010). Vilasanti et al. (2010) reported forage replacement values of 0.52, 0.51, and 0.52 kgs of forage replaced for every 1 kg of supplement fed for mixtures of 40:60 WDGS:grass hay, 30:70 WDGS:grass hay, and 40:60 WDGS:straw, respectively.

In Exp. 2, pairs consumed 17.4 and 17.7 kg of forage for the CON and SUP cattle, respectively, based on calculations of forage intake at 2.3% of pair average BW (Meyer, 2010). Supplemented pairs consumed 6.54 kg/pair/d of the 30:70 MDGS:cornstalk fresh mixture. Therefore, supplementation replaced 36.3% of grazed forage intake. These results are similar to replacement values reported by Weber et al. (2012) in which a 30% MDGS and 70% crop residue was supplemented to growing cattle. In this experiment, a 30% MDGS and 70% cornstalk blend mixed fresh replaced forage DMI by 33.7%.

Crop Residue and ByProduct Blends

Crop residue and by-product mixed fresh (at feeding time) may be as palatable as ensiled material. In the first experiment, dry cows consumed an ensiled mixture for the majority of the time. Throughout the grazing season it appeared that the ensiled mixture was not getting fed fast enough, and quality deteriorated in the bag. Consequently, supplement intake decreased. Weber et al. (2012) saw similar results feeding a MDGS (30% diet DM) and wheat straw (70% diet DM) ensiled blend (30% DM) to growing steers. Low intakes were attributed to slow rates of feeding and spoilage within silo bags, which may have negatively affected the palatability. When the ensiled mix was fed, cows consumed 4.83 kg/d of the supplement. However, during the 28 d the blend was mixed and fed fresh daily, supplementation consumption increased to 8.28 kg/hd/d.

It may be necessary to feed more byproducts to encourage cows to eat the mix rather than grass early in the grazing season. The ratio can then be reduced later in the season. Forage quality is highest at the beginning of the grazing period, competing with the mixture. Quality then declines during mid-summer and then gradually increases at the end of the grazing season, as illustrated in Tables 3 and 4. However, by this time, there is not only less forage mass but cows are also accustomed to daily supplementation. In the first experiment, a constant ratio of 35% synergy and 65% wheat straw was maintained throughout the entire grazing period. However, in 2011, pairs were supplemented with a 50:50 MDGS:cornstalks blend at trial initiation to encourage them to eat the mix. The supplement was then altered by increments of 2 percentage units daily until the desired 30:70 mix was achieved.

Feeding less mixture early in the season when smooth bromegrass is abundant and more mix later in the season when grass is scarce may be better than feeding a constant amount throughout the grazing season. In this study, cattle were supplemented at 0.56% of BW at the beginning of the grazing period and gradually increased to 2.25% of BW at the end, targeting 1.15% of BW or 50% of total DM. This strategy may reduce feed refusals and wastage early in the season, as well as keeping grazing pressure more constant over the grazing period.

Implications

Based on results from these experiments, by-product and crop residue blends have the potential to replace forage intake of cattle grazing smooth bromegrass pasture by up to 40%. The palatability of byproducts encourages cattle to eat the mix, while the crop residue provides a fill effect. Additionally, mixing supplement at time of feeding improves consumption and has potential to replace more forage rather than feeding an ensiled mix. Altering byproduct and residue blends early in the grazing period as well as feeding different amounts throughout the grazing season may prove to be successful rather than feeding the same ratio and amount. Byproducts and crop residues may be a successful supplement strategy for producers to consider for forage replacement of cattle grazing smooth bromegrass pasture.

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Table 1. Rainfall during the growing season 2010 – 2011 (mm).

Month	2010	2011
April	32.3	81.8
May	14.2	173.5
June	106.4	116.6
July	172.0	49.3
August	63.2	108.5
September	86.4	21.8
Total Precipitation	474.5	551.5

Weather for Ithaca, NE
Available at http://www.wunderground.com. Accessed 29 October 2011

Table 2. Forage quality by treatment over entire grazing period.

Variable	CON[1]	SUP[2]	SEM	P-value
2010				
In-vitro DMD (%)	55.9	55.1	3.5	0.87
CP (%)	17.9	16.8	0.6	0.20
NDF (%)	60.4	58.6	1.8	0.48
2011				
In-vitro DMD (%)	60.2	57.0	2.5	0.66
CP (%)	18.9	18.9	0.7	0.39
NDF (%)	59.5	59.7	1.5	0.83

[1]Cattle grazed at recommended stocking rate and received no supplementation.
[2]Cattle grazed at double the recommended stocking rate and received 50% of estimated daily intake of 35:65 synergy:wheat straw mixture.

Table 3. Main effects of time on diet sample characteristics of smooth bromegrass pasture in Exp. 1 (2010).

	Month						Probabilities[1]		
	May	June	July	Aug	Sep	SEM	Linear	Quad	Cubic
In-vitro DMD (%)	67.6	62.4	60.6	55.5	49.8	1.5	<0.01	0.25	0.86
CP (%)	16.3	19.2	19.2	19.7	20.1	0.7	<0.01	0.09	0.19
NDF (%)	61.4	62.8	59.1	55.9	58.9	1.5	0.02	0.53	0.02

[1]Probabilities of linear, quadratic, and cubic effects determined by orthogonal contrasts.

Table 4. Main effects of time on diet sample characteristics of smooth bromegrass pasture in Exp. 2 (2011).

	Month			Probabilities[1]		
	May	July	September	SEM	Linear	Quad
In-vitro DMD (%)	65.7	49.1	53.3	2.8	0.01	0.01
CP (%)	17.1	17.5	17.3	0.7	0.91	0.81
NDF (%)	64.9	55.2	59.2	0.6	<0.01	<0.01

[1]Probabilities of linear and quadratic effects determined by orthogonal contrasts.

Table 5. Cows grazing smooth brome grass pasture animal performance and grazing results 2010

Variable	CON[1]	SUP[2]	SEM	P-value
Initial BW, kg	576	578	1	0.33
Final BW, kg	710	720	12	0.62
ADG, kg/d	0.98	1.04	0.09	0.67
Forage intake	13.6	8.34		
Supplement	-	5.46		

[1]Cattle grazed at recommended stocking rate and received no supplementation.
[2]Cattle grazed at double the recommended stocking rate and received 50% of estimated daily intake of 35:65 synergy:wheat straw mixture.

Table 6. Cow/calf pairs grazing smooth brome grass pasture animal performance and grazing results 2011

Variable	CON[1]	SUP[2]	SEM	P-value
Cow				
Initial BW, kg	581	578	10	0.86
Final BW, kg	618	634	13	0.49
ADG, kg/d	0.27	0.41	0.06	0.22
Calf				
Initial BW, kg	93	94	8	0.97
Final BW, kg	249	289	2	0.06
ADG, kg/d	1.14	1.19	0.07	0.65
Forage intake, kg/pair	17.4	11.5		
Supplement, kg/pair	-	6.54		

[1]Cattle grazed at recommended stocking rate and received no supplementation.
[2]Cattle grazed at double the recommended stocking rate and received 50% of estimated daily intake of 30:70 MDGS:cornstalk mixture.