New Perspectives on Adapting Cattle to Finishing Diets Without Compromising Rumen Health

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Introduction

Adapting cattle to the finishing diet is a critical time during the feeding period that has long-term ramifications. The importance of this period has been reinforced by an increasing number of calf-feds and average days on feed in the cattle feeding sector. Successful adaptation to the finishing diet can result in cattle quickly reaching peak performance and consistent profitability. However, mistakes during the transition can persist and lead to digestive upsets, health complications, and unrealized growth during the remainder of the finishing phase. While weaned calves are functioning ruminants, the microbes in their forestomach have not reached their maximum digestive capabilities. As their microbial communities are maturing, avoiding management missteps can be key to preventing rumen-based maladies later.

The importance of the rumen and its microbes to cattle nutrition and production efficiency has long been established. However, a newfound understanding of the rumen microbiome and gut physiology has generated new emphasis in this area of livestock production. Recent research has investigated practical solutions to improving performance during the transition phase as well as understanding the development of the rumen and its microbial communities. To make profit-driven management decisions in this changing landscape, cattle feeders must understand the basics of rumen function that underlie best feeding practices to evaluate the consequences of market-based choices affecting cattle management.

Importance of Rumen Function and Health

Fermentation in the rumen is responsible for harvesting the majority of the energy for the ruminant animal. When it is functioning well, the rumen is the ideal place for anaerobic bacteria to efficiently digest feed; the rumen is warm, properly mixed, appropriately buffered, regularly provided with substrate (feed), and free of oxygen. Indicators of rumen function can include rate of VFA absorption, motility patterns, rumen papillae histology, and microbial digestion of feed and fiber. Beyond the digestive contributions of the rumen, it also serves an immune function as a protective barrier from microbial inhabitants. In the context of feedlot cattle, the rumen will experience more challenges to the natural equilibrium of rumen function. This is because maximizing weight gain potential by greater energy intake and minimizing of digestive

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upsets are antagonistic goals. To achieve both goals, a balanced diet must be complemented with proper feeding management.

A growing appreciation of rumen and gut health have led to novel techniques to monitor the rumen in commercial and research environments. Ruminal pH can be monitored continuously in cannulated and non-cannulated animals using an indwelling bolus equipped with a pH sensor. There are several types of commercially available pH boluses that are currently being marketed primarily to the dairy industry and researchers. Monitoring ruminal pH is one of most informative measures of fermentation and can indicate how animals are adapting to a new diet. The epithelial tissue is the rumen has garnered more interest recently from a development and functional standpoint. Tissue biopsies of the ruminal papillae are being used in research to understand the function of the rumen wall. While the epithelial tissue has multiple cell types, the overall gene expression pattern and individual protein abundance can be monitored using new sequencing platforms. Culture-independent methods have redefined our understanding of rumen microbial communities. As microbiome evaluations become routine with the maturation of the science, opportunities to use the technology in a production setting will increase.

Common Challenges to Rumen Health

Economic and genetic factors have altered common cattle feeding practices in recent years. From 2010 to 2016, average hot carcass weight increased from 835 lbs to 880 lbs (NASS, USDA) with greater days on feed and moderating feed prices. Over the same time span, the occurrence of liver abscesses increased 25% up to 19% of slaughter cattle evaluated using industry monitoring services. With additional regulations on feeding tylosin to feedlot cattle in the Veterinary Feed Directive and a host of new, “natural” feed additives being released, priorities within the cattle feeding sector have led to a renewed interest on rumen and lower gut health.

The feedlot sector has historically focused on gut health by preventing rumen-related maladies. Common challenges to rumen health include acute and subacute acidosis, bloat, laminitis, rumen ulcers, and liver abscesses. These conditions are often not observed in isolation but are often interrelated. Acidotic conditions in the rumen are driven by the rapid production of organic acids that exceed the rate of absorption by the rumen wall to result in a depressed ruminal pH. Generally, acute acidosis is defined by a pH below 5.0, while subacute acidosis is defined by a pH between 5.0 and 5.6. When ruminal pH is above 5.6, rumen health will be improved by greater motility, increased fiber degradation, and improved barrier function by the rumen wall. The difficulty of measuring pH in a production setting can make diagnosis more challenging. Acute acidosis results in more noticeable symptoms; these may include large decreases in feed intake, recumbent animals with their head in their flank, an absence of ruminal contractions, and severe dehydration. Lactic acid accumulates in the rumen during acute acidosis and further reduces pH while increasing osmolality. The osmolality gradient concentration causes water to diffuse from tissues into the rumen resulting in dehydration and diarrhea. The rapid influx of water can also damage the rumen wall and lead to a rumen ulcer or rumenitis. In contrast, subacute acidosis would typically

only cause a moderate reduction in feed intake, loose stools, and some signs of colic. The long-term occurrence of subacute acidosis will likely decrease performance and fiber digestion, but this has been difficult to document the magnitude of effect in a research setting.

Although commonly described as two distinct conditions, acidosis exists as a continuum of symptoms with greater severity often causing subsequent ailments. When acidosis disrupts the barrier function of the rumen wall, liver abscesses can occur. A breach of the rumen epithelium allows bacteria to enter the bloodstream to be transported to the liver. While not a predominant bacterium in the rumen, *Fusobacterium necrophorum* is an opportunistic pathogen found in liver abscess infections. Tylosin is a feed grade antibiotic fed to the majority of feedlot cattle (80%; Samuelson et al., 2017) to prevent liver abscesses. Tylosin is effective at reducing liver abscesses, but it does not change the precursor events that lead to the development of liver abscesses including a decreased rumen pH and damage to the rumen wall. Beyond the health implications of an active infection, severe liver abscesses decrease growth performance and cost slaughter facilities $20-80 in carcass value per animal (Brown and Lawrence, 2010). The recent implementation of the Veterinary Feed Directive and continued public pressure on the use of feed-grade antibiotics in livestock production will continue to impact nutritional management of cattle in the future.

Bloat is the easiest form of digestive upset to diagnose in feedlot cattle. An accumulation of gases trapped within the rumen causes distension on the left side of the animal that can range from mild to severe. Although several variations of bloat exist, frothy bloat is the most commonly observed in the feedlot and frequently occurs from 100-120 days on feed (Vogel et al., 2015). The formation of stable foam prevents eructation from expelling the gases from the rumen. Treatment of bloat includes passage of a stomach tube, administration of mineral oil, or use of a trocar for a rumenotomy. Because acidosis can affect ruminal contractions, saliva production, and the bacterial community, the stagnation of rumen can lead to gas accumulation and bloat (Meyer and Bryant, 2017).

Recent Research Findings

One of the primary risk times during the feeding period for digestive upsets is when animals are being transitioned to a finishing diet. Calves are typically adapted to a finishing diet during the 14 to 28 days after arrival. The goal of this period is to slowly adapt the rumen microbes to a higher concentrate inclusion in the diet. This can be successfully achieved by making moderate increases in feed calls while also making planned dietary adjustments. It is important not to increase the feed provided on the same day cattle are stepped up to a new diet. While a conservative approach is often used from a diet and management standpoint, there may be unrealized gain potential during this period since cattle are consuming diets with moderate energy. Also, these transition diets have the greatest inclusion of high-quality forage and can be the most difficult to mill. Feeding forage requires dedicated areas for proper storage, specialized machinery, and substantial time for grinding. Drought can have a major effect on regional forage prices. High levels of forage in the diet may also exceed the

requirements for rumen degradable protein in young, growing calves based on the new guidelines in the 2016 Beef Cattle Nutrient Requirements Model (BCNRM). The 2015 feedlot nutritionist survey revealed that the most common method for adapting cattle to a finishing requirement used 4 step-up diets with each provided for an average of 6 days (Samuelson et al., 2016). In smaller feedlots, using fewer step-up diets for a longer period may simplify feeding multiple groups of cattle and provide more acclimation time to each diet before the next change.

Recent research has also investigated the long-term consequences of different transition strategies on overall finishing performance. If cattle are truly more adapted for the finishing diet, then they should exhibit an advantage that extends beyond the transition period. Work conducted at the University of Illinois has shown that coproducts can replace most of the forage in transition diets to increase the energy content without adding starch and greater risk of digestive upset (McCann, unpublished). Multiple experiments from the University of Nebraska support the fact that management and nutritional decisions over this adaptation period can have long-lasting effects during the remainder of the finishing phase. Huls et al. (2016) observed that cattle adapted to a silage-based finishing diet using corn gluten feed (Sweet Bran, Cargill Corn Milling) had increased growth performance and feed conversion compared with cattle adapted using primarily alfalfa. Another experiment evaluated the ability of a complete starter feed (RAMP, Cargill Corn Milling) to adapt cattle to the finishing diet (Schneider et al., 2017). Cattle performance increased when fed RAMP compared with a more traditional, alfalfa-based adaptation diets. Collectively, this body of work indicates nutritional strategies during the transition period can improve the adaptation of the rumen microbiome and translate to a performance advantage.

Many non-nutritive feed additives such as direct-fed microbials have also been evaluated early in the feeding period. The diversity in the strain and species of the organisms present in these additives coincides with the diverse potential modes of actions and highly variable animal responses observed. There are many yeast-based products on the market, and they have been most extensively studied in the dairy industry. While there is some evidence yeast-based products can ameliorate aspects of subacute ruminal acidosis (Chiquette et al., 2015), many of the proposed modes of action (Jouany, 2006) have not been evaluated in a feedlot cattle context. Additionally, many of the additives may not target changes in rumen fermentation, but rather affect intake, stress, morbidity, or lower gut populations. Although most direct-fed microbial strains are not of rumen origin, recent work has evaluated the effect of dosing a robust, rumen-derived strain of *Megasphaera elsdenii*, a well-characterized lactate utilizer in the rumen (Henning et al., 2010). In a receiving cattle study, dosing with the *M. elsdenii* strain allowed cattle to be rapidly adapted to a finishing diet in only 10 days and reduced ruminal lactate concentrations (Ellerman et al., 2017). As the market for microbial feed additive continues to expand, evaluating strain-specific responses in the appropriate animal context will be important to demonstrate consistent effects and value to producers.

Reducing the incidence of digestive upsets in the feedlot will increase cattle performance and health to drive profitability, but many challenges exist. The latest

National Animal Health Monitoring System survey indicated 71% of feedlots were affected by digestive problems. However, it also described the greatest challenge with these issues: diagnosis prior to death. The ratio of mortality to morbidity for digestive problems was 159% compared with pneumonia which was 3.79%. Prevention of digestive upsets is critical considering our poor ability to detect their early onset.

It is well established among nutritionists that most of the problems with digestive upsets are rooted in management rather than the diet formulation. Although their opinion may have some level of bias, many implementation steps do alter the diet composition from the formulation to what is actually consumed by the cattle. In essence, variation or change is the enemy when feeding cattle a high concentrate diet. A range of management factors can reduce the risk of digestive upsets if done well and include bunk calls, ration mixing, ration delivery, feedstuff management, grain processing, and monitoring of cattle sickness. These are the primary opportunities to reduce man-made variation and prevent it from compounding the animal-to-animal variation that already exists. The level of individual animal variation in cattle on feed can be evaluated using the GrowSafe feed bunks that measure each animal's feed intake. While feed intake may remain consistent for a large group of cattle on feed, within the group, feed intake changes significantly on a day-to-day basis. Research at the University of Illinois has indicated some cattle may be particularly inconsistent, fluctuating more than 30% in dry matter intake on nearly 50% of the evaluated days. Recognizing the inherent animal variation further emphasizes the need for consistent management practices.

The transition to the finishing diet was historically considered the time with the greatest risk for acidosis. However, recent findings have indicated that the occurrence of acidosis increases with additional days on feeds (Castillo-Lopez et al., 2014). While the study was not large scale, it was able to collect consistent ruminal pH measurements throughout the finishing phase. Cattle are clearly adapted to the finishing diet near the end of the feeding period, so there must be a different factor initiating the acidotic events. During the finishing phase, minor acidotic insults accumulate and appear to condition the microbial community and the ruminal epithelium. Additional days on feed also increase the opportunity for an off-feed event to occur. A repeated subacute acidosis challenge was conducted at the University of Illinois to further understand the etiology of the acidotic events (McCann et al., 2016). During the initial two challenges, only one of the 12 cattle actually acquired acidosis despite different levels of challenges implemented. However, during the third challenge, all but one animal experienced subacute acidosis. The results indicate that minor events can prime the system over time for an acidotic event to occur later.

Conclusions

Ever-changing market and consumer signals will continue to drive our cattle feeding decisions, but nutritionists must be prepared to make the necessary adjustments to maintain and improve cattle performance levels. Challenging the status quo in preparing cattle for a finishing diet may be one opportunity to meet these

demands. Seeking and obtaining improvements in rumen health can also demonstrate our commitment to animal health and well-being to beef consumers.

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SESSION NOTES