Nutritional management between health and performance

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Abstract

The goals of finishing beef cattle include improving cattle performance and efficiency, producing a product that meets the standards of the consumer, and creating good animal husbandry and health for the cattle. Proper management and feeding of finishing cattle can have a huge impact on disease incidence. Feeding high energy diets will drive an improvement in efficiency by reducing losses of carbon dioxide and methane gas. This improvement reduces the cost and resources of producing beef. An issue is that cattle are accustomed to consuming grasses and not nutrient-rich diets, thus they require an adaptation period. Good management of formulation and delivery of feed is key to reduce the likelihood of negative impacts during this period. Bovine respiratory disease is the most prominent disease in this population of cattle. This paper attempts to outline the impact of acidosis and bovine respiratory disease as well as other feed-related diseases commonly seen in feedlot cattle such as rumen tympany or bloat, acute or atypical intersitial pneumonia, and laminitis.

Key words: feedlot cattle, acidosis, bovine respiratory disease

Résumé

La finition des bovins de boucherie vise plusieurs buts incluant l'amélioration de la performance et du rendement des bovins, la production d'un produit satisfaisant les normes des consommateurs, la création de bonnes pratiques d'élevage et l'amélioration de la santé des bovins. La régie et l'alimentation adéquates des bovins de finition peuvent avoir un impact majeur sur l'incidence de la maladie. Offrir des régimes à haute teneur en énergie va augmenter le rendement tout en réduisant les pertes en dioxyde de carbone et en méthane sous forme gazeuse. Ces améliorations vont réduire les coûts et les ressources nécessaires pour produire le bœuf. Un problème subsiste tout de même car les bovins sont habitués à consommer de l'herbe et non pas des aliments riches en nutriments ce qui nécessite une période d'adaptation. Une bonne régie de la formulation et de la distribution des aliments est un élément important afin de réduire la probabilité de répercussions négatives durant cette période. Le complexe respiratoire bovin est la condition la plus fréquente dans cette population de bovins. Cet article tente de circonscrire l'impact de l'acidose et du complexe respiratoire bovin de même que celui d'autres maladies reliées à l'alimentation qui sont fréquentes chez les bovins en parc d'engraissement comme le tympanisme du rumen ou ballonnement, la pneumonie interstitielle aiguë ou atypique et la fourbure.

Goals of Finishing Beef Cattle

An appropriate starting point for this discussion is to talk about the overarching goals of finishing beef cattle. While the economics are certainly important for the producer to stay in business, animal husbandry and care must also be a strong consideration. Cattle morbidity and mortality can be drivers of economics as well. Busby showed that cattle administered a single treatment at the feedyard had significant reductions in average daily gain (ADG), feed conversion (F:G), USDA Quality Grade, USDA Yield Grade, and profitability.[3] The common theme for this paper is discussing the conflicting issues between cattle health and cattle performance. Marketing cattle on a live basis, maximizing ADG, and F:G are major drivers of profitability. In short, putting on the most pounds at the least cost. Producers marketing cattle on a grid-based system (also known as formula cattle) have other considerations or targets to achieve, depending on the specific negotiated grid. Commonly, these targets include USDA Quality Grade, yield or dressing percentage, USDA yield grade, and carcass weight. Capitalizing on several targets can be difficult to achieve in a common cohort of calves, like a single producer's calf crop as an example. The challenge becomes marketing a larger proportion of the population at the ideal slaughter weight, percent body fat, etc. Producers feeding large numbers of cattle at any given time will likely sort the cattle either on arrival to the feedyard, further along in the feeding period like 60 to 90 days from harvest, or both. While this is a key practice for the performance side of the business, it can create problems on the animal health side. Commingling of cattle may cause problems with animal health. O'Connor et al found increased feedyard morbidity in commingled compared to single-source pens of cattle (odds ratio 2.9, P<0.001).[18] Commingling yields additional stress on the cattle, but biosecurity and disease transmission risks are elevated as well. Further, if the feedyard buys a group of cattle that begin to exhibit high morbidity and mortality, you have now taken the problem and dispersed it over several different pens. This reduces the ability of the feedyard to provide additional attention to the problem source, and they may also lose track of which group of cattle where the problem began, preventing a solid conclusion for future procurement decisions.

Feedlot Cattle Diets

Cattle have the unique ability to utilize dry grasses and convert them into a protein that humans can consume. A new term utilized is "Upcycler." Briefly, it is important to note that for most of their life, cattle are eating forage in some form or fashion. In the feedyard, cattle must consume more energy-dense feed to increase their ADG, F:G and improve carcass quality traits. Energy-dense feeds would include cereal grains, sources of fat, and by-products from other cereal grain processes. Furthermore, a variety of grain processing methods are utilized to increase the nutrient yield from these feeds. Examples include steam-flaking, rolling and ensiling at a higher moisture, finely grinding, and dry-rolling. Forage or roughage must be maintained at some level in feedyard diets to promote rumen health and salivation (buffering). Economical feeding of cattle prevents using the higher levels of forage that beef and dairy cows are typically fed, due to the dilution of energy with forage. Optimal rumen pH for digestion differs largely due to variation in the organic acid yield of grain vs forage fermentation. Grains yield higher total organic acid production as well as have a lower ratio of acetate:propionate, which is advantageous from a biochemical standpoint as less carbon is lost as carbon dioxide and methane gases in the metabolism of propionate compared to acetate.

Added sources of fat, such as bleachable tallow and corn oil, are commonly fed in feedlot diets to increase the energy density without increasing soluble starch in the diet. Adding fat has not been shown to improve the incidence of subclinical acidosis in cattle fed dry-rolled corn diets.[12] Ethanol co-products, such as distillers' grains and corn gluten feed, are popular for use in feedlot diets. With corn co-products, the distillation process removes most of the starch cereal grain,[13] which may be fed wet or dried to 50 or 90% dry-matter. Depending upon inclusion rate, the minimal amount of starch in these co-products may help prevent acidosis by reducing rapidly fermentable carbohydrate load. Wet corn gluten feed is a co-product of corn wet-milling and has similar starch content of distillers' grains, reducing the area of the curve of rumen pH below 6.0 and reducing 24-hour VFA accumulation compared to dry-rolled corn when dosed intra-ruminally to fistulated steers.[11] There is also evidence that sorghum distillers' grains may reduce repulls and the number of days cattle were observed as morbid.[8]

The Transition

As discussed earlier, finishing cattle cannot optimize digestion of a 50% forage and 50% concentrate diet, so the transition from high roughage to a high-energy diet is an important part of the balance between feeding performance and animal health. There are differing opinions on the best way to accomplish transitioning cattle. Typically, developing multiple rations or steps (4 or 5) that gradually increase ratio of concentrate are used successfully. Another method is utilizing 1 high forage ration (starter) and 1 high concentrate ration (finisher), commonly referenced as the "2-ration system". These diets are fed on different times of day and cattle are proportionately moved from more of the starter diet to more of the finisher diet over several days. With either method, the timing is critical as cattle must be given adequate time to transition, and the success of this dynamic process is dependent upon many other factors.

When referencing transitioning cattle, the predominate understanding is changing the ratio of rumen microflora from cellulose-degrading bacteria to starch-degrading bacteria. The importance of changing the rumen bacterial population is accurate, however, other rumen dynamics must transition as well. Because there is more mM of organic acid produced with the fermentation of cereal grains vs forages, the capacity of ruminal VFA absorption must be adequate to moderate rumen pH fluctuations. Rumen papillae structure and health play important roles in this dynamic and will be discussed later in the relationship with sub-clinical acidosis and founder. Another important transition is consuming to a physical fill on a forage-based diet compared to consuming to chemotactic satiety on a grain-based diet. This transition required time due to a delay in messaging from the GI tract to the brain, so proper feed calls and deliveries are paramount during this time to minimize digestive upset.

The Bovine Respiratory Disease Complex and Feed-Related Problems

Respiratory disease in feedlot cattle has a multitude of causitive agents ranging from microbial (bovine respiratory syncytial virus (BRSV), parainfluenza type 3 (PI-3), infectious bovine rhinotracheitis (IBR), bovine viral diarrhea virus (BVDV), *Mannheimia haemolytica*, *Pasteurella multocida*, *Histophilus somni*, *Mycoplasma* spp) to social and environmental stressors (transport, commingling, stocking rate, dietary, temperature, wind, dust, humidity) to genetic heritability of BRD resistance.[22] Microbial pathogens are generally ubiquitous in feedlot cattle populations and bacterial pathogens are commensal in healthy cattle, but immunosuppression of the animals through stressors described above can induce clinical disease.[5] The majority of BRD treatments occur in the first 45 to 80 days-on-feed.[21,22,25] During this period, cattle are exposed to many stressors and transitioned to increasing levels of cereal grains as described above. Stressors such as comingling, excessive handling, and dietary change will decrease the animal's immune function through the HPA axis and release of glucocorticoids, or through activation of the sympathetic nervous system, leading to a reduction of natural killer cells.[16] In addition to the stress caused by dietary changes, opportunities for acidosis from increased production of organic acids increase. Excessive daily variation in intake of cereal grain diets is a common source and result of acidosis.[20] A similar situation exists with clinical

BRD cases with depressed feed consumption for several days due to pro-inflammatory cytokines followed by increased and compensatory consumption of excess quantities when the BRD symptoms subside. Lower feed intake has been shown to be associated with clinical BRD in receiving calves.[19] Accumulation of organic acids and rumen pH depression causes a successive reduction in blood pH due to loss of bicarbonate and increased concentrations of acids.[20] Strong positive correlations were observed between blood pH and lymphocyte proliferation to BVDV and PI-3 antigens.[7] In this study, 1 treatment was designed to induce feedlot acidosis. Lymphocyte proliferation to *Staphylococcus aureus* exotoxin B, BVDV, and bovine herpes virus-1 was lower in cattle given the acidosis-inducing diet compared to controls.[7] Ruminal pH depression from increased organic acid concentration causes endotoxin release from dead gram-negative cells into circulation.[17] Endotoxin has been shown to consume components of the complement cascade[9] and increase the release of pro-inflammatory compounds from polymorphonuclear cells, increasing damage to lung tissue during BRD[28] along with cytotoxic effects on bovine mononuclear leukocytes.[2] The figure below is a proposed schematic representation of the association between BRD and ruminal acidosis.

Other Common Feed-Related Feedlot Diseases – Gas Bloat and Acidosis

Feedlot bloat and acidosis are highly correlative. Typical death losses can vary from region, season, and management styles. Typical incidence of mortality from bloat must be weighed against the accuracy and the diligence of necropsy, as many dead longer-fed cattle may exhibit postmortem bloat from other causes of death. The importance of accurate necropsy in appropriately investigating any feed-related mortality issues in beef cattle cannot be overstated. When accurate necropsy is conducted, a typical incidence will range from 0.025 to 0.04% of inventory on a monthly basis. Variation exists based on days-on-feed, grain processing, weather patterns, and bunk management.

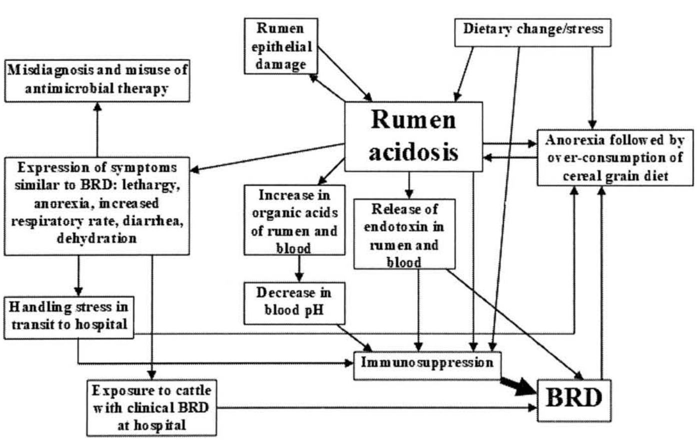

Figure 1. Proposed association between and among bovine respiratory disease and rumen acidosis in feedlot cattle.

Troubleshooting bloating can be challenging for veterinarians because the ration formulation and delivery are typically outside their jurisdiction. However, there are several areas that a consulting veterinarian can appropriately investigate.

1. Cattle that bloat with a prior treatment history of BRD could have associated mediastinal lymph node damage, which predisposes the animal to vagal nerve dysfunction. If a high proportion of bloats have treatment history, the root cause may be lung and associated vagal nerve damage. Preventing and reducing the severity of BRD would be an appropriate strategy.
2. If bloats are limited to certain pen or locations in the feedyard, it is prudent to look for underlying causes and patterns. Do some pens get overstocked? Do certain locations of the feedyard get fed inconsistently? Does the occurrence of bloat follow a weekly pattern suggesting a personnel or management issue on weekends?
3. If bloats are distributed evenly across the yard, the top areas of consideration would be the formulation, mixing and/or delivery of the diet. Formulation of the diet requires the appropriate balance of energy with protein. It also requires a minimal level of effective fiber to maintain the mat on the surface of the rumen contents.
   - Steam flaked corn increases the starch availability and rumen digestion kinetics. Flaking improves performance, but also increases the risk factors associated with digestive upsets. The consistency of flaking cannot be overstated. In fact, the consistency of the flakes regarding moisture and starch availability may be more important than the actual target for moisture, flake weight, and starch availability. The flakes also have a limited shelf life and fall out of condition. This can cause bloats to increase during or immediately after weekends or on holidays when the flaking process may get disrupted due to personnel changes.
   - The balance of rumen degradable protein (RDP) with steam flaked grains is important. If the RDP is inadequate, rumen microflora will not reproduce and enter maintenance mode, whereby they create more organic acid and produce less microbial cell protein. Non-protein nitrogen (NPN) sources such as urea are commonly used to provide adequate RDP.
   - Many feedyards utilize different sources of fats from plants and animals. It is noteworthy that fats come in different forms and differ in quality. The old rule of thumb typically applies, in that you get what you pay for. Lower-quality fat sources may not be stabilized with antioxidants or be inconsistent. When the incidence of bloats

is consistent throughout the week with cattle fed diets with 6to 7% fat DM, it would be prudent to check the oxidation levels. Fat with high levels of peroxides will cause rumen microflora disruption, predisposing bloats in cattle on high-energy diets.
- Ration formulation for high performance cattle feeding is designed for maximum energy density. Effective fiber is energy dilutive in the diet, so nutritionists often attempt to minimize this component while still maintaining adequate levels to maintain rumen function. Typical levels of forage will range from 15% to as low as 6%. When low levels of forage are formulated, it is imperative that the fiber has enough length to create the rumen mat, but not too long to allow the cattle to sort it. Sorting can be a significant contributor to inconsistency in the diet the cattle actually consume. A common remedy for excessive bloating is adding additional fiber. While this is a logical approach, if the fiber is not processed appropriately the outcome may be disappointing due to additional sorting.

4 If the formulation of the diets is appropriate, another area of investigation should center around the consistency of delivery and mixing. It is commonly noted that 3 rations exist: the ration that is formulated, the ration that is mixed, and the ration that is consumed.
- The delivery of high-energy rations must be consistent in content, and also consistent in delivery times. Variances in excess of an hour can be problematic, and management should work to minimize the delivery time variance to under 30 minutes.
- Good feeding managers should track the ingredient loading variances and be able to provide a report that quantifies the amount of each individual ingredient called for in the ration in comparison to the amount that was actually mixed. Excess variances in these ingredients can provide another source of inconsistency that may cause underlying digestive upsets as well as reduced performance.

Other Common Feed-related Feedlot Diseases – Acute or Atypical Interstitial Pneumonia

The condition is presently thought to be an allergic response to particular rumen gases and/or compounds. Classic pasture AIP (fog fever) can occur in cattle that are fed on dry forage for an extended period of time and then placed on lush pasture. DL-tryptophan is converted to 3-methylindole (3-MI); 3-MI is thought to be the toxic compound that creates the lung lesions. The classic pasture AIP pathophysiology is well characterized, in contrast to feedlot-associated AIP. Feedlot-associated AIP has lesions histologically similar to pasture AIP, but the cause of this condition remains unclear. The following points summarize the current understanding of feedlot-associated AIP.

1. Feedlot-associated AIP is seen in feedlot cattle primarily during the months of May through September. The onset is rapid and case fatality can range from 50 to 60%.[23] It is the second-costliest disease to the cattle industry after BRD due to the highest occurrence late in the feeding period when the animal is most valuable.[1,23]
2. Treatment is generally unrewarding and pen-riding to identify, pull, and treat those showing clinical signs generally does not change the outcome.
3. The lung lesions on necropsy are unique, in that there are areas of normal lung interspersed with areas that have a meaty texture. Many times, the dorsal (top) portion of the lung is involved, which is exactly the opposite of bacterial pneumonia, where the primary involvement is in the ventral (bottom) portion of the lung.
4. Bovine respiratory syncitial virus (BRSV) has been incriminated as the etiology for this condition in the past. However, more recent characterization of this relationship between infectious agents and AIP is inconclusive.[15]
5. Cattle that are necropsied with confirmed AIP have a high (6.0 to 7.0) rumen pH, which is in contrast to those dying from bloat having a pH of 4.9 to 5.4.[26] The rumen pH on normal cattle on high-concentrate ration usually ranges from 5.3 to 6.0. This suggests a digestive-related pathophysiology of the disease, much as low pH is related to acidosis and subsequent bloat.
6. There appears to be a genetic and gender predisposition. The incidence of AIP is lower in Holstein and Mexican-sourced cattle. There has been a higher incidence of AIP in heifers than steers, and of those dying, ovarian activity is typically noted.[23]

The nutritional relationship with AIP remains unclear. However, there are several hypotheses. First, the higher incidence in heifers suggests an involvement with estrogenic hormones. Stanford et al found that melengestrol acetate (MGA) increased the susceptibility of the lung tissue to 3-MI, and concluded that removing MGA from the diet could be a cost-effective method of prevention.[23] Second, eructation of hydrogen sulfide gas has been postulated as an irritant to alveolar cells, suggesting a link with excess sulfur in the diets from ethanol co-products. This relationship is still unclear. Third, excess diet variation due to inconsistent delivery time and/or nutrient content has been postulated to increase the risk of AIP. While the authors anecdotally agree with this hypothesis, Valles et al did not report any significant interaction between diet variance and the incidence of AIP.[27]

Other Common Feed-related Feedlot Diseases – Founder/Laminitis

Founder in feedyards presents a unique challenge. The cause and the effect of this disease may be months apart and are irreversible. Calves exposed to chronic subclinical levels of lactic acidosis during the growing phase are at risk of developing founder late in the feeding period. The pathophysiology typically follows a pattern of an acidotic insult during the growing phase which damages the rumen papillae (rumenitis), subsequently reducing the VFA absorptive capacity of the rumen. The result is higher fluctuations of rumen pH, leading to vasoactive agents such as histamine and endotoxin entering circulation and causing vasoconstriction in the laminar region. This eventually results in rotation of the distal phalanx. Research also shows correlation between liver abscesses and founder, which supports the nutritional association with ruminal acidosis.[10]

Prevention of this disease is the only viable strategy as palliative therapy and corrective trimming are generally unrewarding. The key areas of prevention are:

1. Starting calves on low-starch diets and gradually adapting to high-starch diets.
2. Use of ionophores will reduce rumen pH fluctuations and lactic acid levels.
3. Consistency of ration delivery, grain processing, and ration ingredient variance. This is especially important for all-natural feeding regimens that disallow ionophores.

Feed Additives Commonly Fed to Prevent Digestive Diseases

Ionophores such as monensin[a] are commonly fed to cattle for prevention of coccidiosis and improving feed efficiency. An additional benefit observed with monensin is the reduction of acidosis through modulation of feed intake and rumen fermentation.[6,14,24] Cooper et al used continuous monitoring of pH to evaluate the impact of monensin on rumen pH.[4] In this trial, monensin reduced acidosis by increasing average rumen pH, decreasing the rumen pH area under the curve of 5.6, and stabilizing feed intake.[4] Ionophore levels must be appropriately formulated to allow maximum prevention of rumen acidosis and bloats. Consistent delivery of the medications can be determined with TMR mixing tests which the company representatives perform routinely or upon request.

Conclusion

In summary, management and proper feeding of finishing cattle can have as big of an impact on disease incidence as utilizing proper vaccination and parasite control programs. It is important for producers to work with nutritionists to develop programs that work with the type of cattle they feed and the marketing channels they wish to target.

Endnote

[a]Elanco Animal Health, Indianapolis, IN

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