Ruminant Session I

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New Information on Corn Co-Products: Implications on Ration Formulation

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Take-Home Message

The "Take-Home" is that beef cattle producers are uniquely positioned to use new and changing co-products. To remain economically viable, co-products should be taken advantage of in beef cattle rations. The key is getting an analysis and knowing what one is dealing with in order to continue to meet animal's requirements. Each scenario may have a different "optimum inclusion" of co-products dependent on cost, availability, roughage inclusion, water source, and the production system, to name just a few. Follow the literature on new information for co-products and don't be afraid to try something new.

Introduction

In traditional beef cattle production systems, corn has ruled. In feedlot settings, up to 80 or 90% of the ration DM would have been corn as recently as the late 90s. However, in the current bioenergy environment, there is a "newfound" reliance on corn grain to provide energy for fuel. This shift in emphasis on corn for fuel instead of feed has driven up the competition for corn grain and, thus, corn grain cost. In an effort to maintain profitability, and in some cases, break even, beef cattle producers have had to seek out new uses for co-products from corn processing industries.

Of course, corn co-products such as gluten feed (CGF) and meal (CGM), and distillers grains (DGS) have been used by beef cattle producers for decades and, therefore, are not necessarily new. However, historically cattle producers have relied heavily on these co-products as supplemental sources of protein and have limited their inclusion in diets to mitigate some of the potential problems with them. For example, in most cases, including the aforementioned co-products at 15 to 25% of the diet DM would meet protein requirements for finishing cattle according to the NRC (2000). More than 20% of these co-products are regularly included in the diet; therefore, protein is fed in excess. Furthermore, elevated fat concentration in cattle diets is known to be antagonistic to fiber digestibility and, thus, a potential limiting factor of DGS, although not a concern with CGM or CGF. Using DGS simply as protein sources limited additional dietary fat and, thus, was not much of a concern. Another factor given much consideration has been S concentration of corn co-products. Again, at 15 to 25% dietary inclusion of co-products (DM basis) S was not a major concern. The largest concern with S is its wide range in variability between and within corn plants (Batal and Dale, 2003). Each of these topics will be discussed in greater detail later in this paper. The best thing about the early use of co-products, however, was the price. Relative to corn, they were a cheap, readily available feedstuff.

Shifting Focus for Corn Co-product Use

More recently, since the corn grain price spike in 2008, there has been a shift in how beef cattle producers think about and use corn co-products. The reality of the future is that less corn and more corn co-products will be available for beef cattle diets (2009). Now, instead of just using co-products as a protein supplements, more and more emphasis has been placed on co-products as energy sources for beef cattle (Leupp et al., 2009; Felix et al., 2011; Radunz et al., 2012). The NRC (2000) reported values for TDN, NE_m, and NE_g for DGS and CGM are similar to those of corn; and, several excellent reviews have indicated that the energy content of DGS, at least, is 20% greater than that of corn (Ham et al., 1994; Klopfenstein et al., 2008; Loy, 2008). However, increasing the inclusion of these corn co-products in the diet exacerbates the aforementioned limits to their inclusion. Because of the methods used to process corn, most of the starch in corn is removed (Bothast and Schlicher, 2005) and the remaining components (primarily fiber, protein, fat, and minerals) are found in DDGS at approximately 3 times the concentrations found in corn grain (Batal and Dale, 2003; Lardy, 2007). Increasing dietary concentration of protein, fat, and certain minerals, namely S, can all have detrimental effects on beef cattle performance.

Excess dietary protein can have a number of impacts on the animal. Excess N in a diet can increase concentrations of rumen ammonia and decrease feed intake (Waldo, 1968). Animals consuming large quantities of N must be able to excrete unused N and this comes at a metabolic cost. The two major pathways of N excretion are through urine and feces (Waldo, 1967). Urinary N is excreted as urea. Early work suggested the cost of N metabolism was because of the necessary conversion of N to urea in the liver for urinary excretion or recycling (Reynolds et al., 1992), which increases at greater N intakes (Waldo, 1967). This net cost of liver ureagenesis for recycling of urea and urinary excretion was calculated as 1 ATP (Reynolds, 1992). However, more recently, the increase metabolic cost of excess N has been attributed to the increase in tissue size (namely the liver) to increase the synthesis of enzymes necessary for the deamination of N (Reynolds and Kristensen, 2008). Regardless of its origin, these metabolic costs represent a potential loss in cattle performance when increasing amounts of N, read corn co-products, are fed. However, as responsible stewards of agriculture, the animal is not the only concern as N inclusion is increased. Increasing environmental concerns have called into question the advisability of including corn co-products in the diet in excess of protein requirements because of the excess N excretion. For example, we know that more than 50% of the protein in DGS escapes ruminal fermentation (Waller et al., 1980; Firkins et al., 1984). This escape protein should be beneficial in meeting the metabolizable protein requirement of growing cattle. However, if excess N excretion occurs, volatilization of ammonia into the atmosphere could result. As protein intake increases, more N is excreted in the urine as urea. Urea is rapidly hydrolyzed in manure by bacterial ureases and almost all urinary N is volatilized. In addition, some fecal N is reactive and volatilizes to ammonia and the combined urinary and fecal ammonia volatilization accounts for more than 90% of the N lost from manure (Eghball et al., 1997). The end result is that as much as 42% of excreted N is lost to the environment (Eghball et al., 1997). Feeding excess N, by including co-products in the diet as energy sources may lead government agencies to impose strict environment regulations on animal agriculture.

The other potential issue with feeding corn co-products as an energy source is the fat. Fortunately, this problem is typically limited to DGS and not CGF or CGM (DGS contain 7 to 10% fat, DM basis, versus ~2.5 to 3 % fat in CGF or CGM; NRC, 2000). Reason for this concern being that it has long been known that dietary unsaturated fat can decrease degradation of fiber in the rumen (Lucas and Loosli, 1944; Swift et al., 1947). However, the degree of fat saturation affects how much can be included before fiber digestibility of the diet is affected (Pantoja et al., 1994; Nelson et al., 2008). As fat saturation increases, it is less inhibitory to fiber digestion (Pantoja et al., 1994). In finishing cattle, when 6% supplementation with either unsaturated or saturated fat was compared, feeding unsaturated fat diet resulted in decreased hemicellulose and NDF digestibility (Nelson et al., 2008). Although it was originally, and logically, assumed that all the fat in DGS would come from corn oil, and, therefore, behave like corn oil, the fat in wet DGS has been evaluated and appears to be less digestible than fat from corn oil (Klopfenstein et al., 2008). However, Leupp et al. (2009) reported that increasing dietary dry DGS from 0 to 60% of the diet did tended to decrease ruminal NDF and ADF digestibility. We now have research data to suggest factors other than the fat may have contributed to this reduction in fiber digestibility.

Those "other factors" begin with S. Not to diminish issues with protein or fat, but most of the concern with increasing corn co-products in the diet has centered around S. However, most of the work on S concentration in corn co-products was not done until as recently as the last 5 years. What changed? Our comfort and ability to test these parameters have surely helped, along with the realization of the issue. Sulfur was not a commonly included mineral in our standard feedstuffs analysis in past years. Furthermore, the NRC (2000) lists the S concentration for CGF, CGM, and DGS at less than 0.5% of the diet DM. As cattle can tolerate as much as 0.4% S in diet, limits of S inclusion may have simply been overlooked for a time. Regardless the reason, S is now noted as one of the primary considerations when feeding corn co-products and is routinely included in the analysis requested by nutritionist of many co-products now. Why the increased concern?

Elevated dietary S can depress intake and decrease ADG (Klopfenstein et al., 2008). Many researchers also believe that high S can cause polioencephalomalacia (PEM) because it increases ruminal H_2S concentration (Gould et al., 1997; Ward and Patterson, 2004; Knight et al., 2008). In finishing beef, diets consisting of over 50% DDGS increased the prevalence of S-induced PEM (Bucker et al., 2007). Knight et al. (2008) tried to use the clay mineral zeolite to bind S and prevent PEM, however, this was unsuccessful. Thiamine injections are commonly given to—and cure—animals exhibiting PEM-like symptoms, which has caused speculation about the effects of S on PEM. However, thiamine treatment has also been effectively used on PEM that was caused by lead (Harmeyer and Kollenkirchen, 1989), suggesting thiamine has an effect on PEM regardless of the causative agent. It is known, however, that increasing corn co-products increase ruminal H_2S concentrations (Felix and Loerch, 2011; Drewnoski et al., 2012; Felix et al., 2012b), a major contributing factor to PEM (Gould et al., 1997).

Obviously, while S completes part of the H_2S equation, the other part is hydrogen ions. Therefore, as pH is driven by the concentration of hydrogen ions, ruminal pH would be expected to impact H_2S concentrations and, potentially, PEM. Recently, Felix and Loerch (2011) reported a direct correlation between ruminal pH and H_2S concentration and suggested that the link between these two is the use of sulfuric acid (H_2SO_4) used in the ethanol production process. These researchers postulated that the acidity, not the S alone, is responsible for reductions in animal performance (Felix et al., 2012b). More recently, the effectiveness of buffering the acidity through alkali treatments of co-products has been demonstrated to improve animal performance (Morrow et al., 2013), as well as ruminal pH and fiber digestibility (Felix et al., 2012a; Morrow et al., 2013). This emerging area of buffering acidity from corn co-products has currently only been tested in DGS-based diets. The optimum level and source of alkali treatment has not yet been investigated. The bottom line is that acidity from S, not increasing fat or protein, is likely what diminishes animal performance and feed digestibility as corn co-products are increased in the ration. This new information suggests that buffering agents may be one additive to consider when formulating rations with corn co-products.

"New" Corn Co-products

A "newer" corn co-product has been gaining attention that could work in tandem to alleviate these issues with acidity in other corn co-products and that is corn stover. Corn stover is the crop residue left after corn harvest and is one of the most abundant in the U.S. (Glassner et al., 1998). Historically, if harvested and not left in the field, corn stover has been used as bedding. Because corn stover is the mature plant, harvested after corn grain, it does not compete with the grain yield for ethanol, like corn silage; however, it is mature, poor quality forage. Over the past few years, there has been a tremendous effort to increase the feeding value of corn stover for feedlot cattle thereby increasing its use (Russell et al., 2011; Shreck et al., 2012).The most popular technique to do this has been treating corn stover with 5% calcium oxide (CaO). This process involves grinding the corn stover, wetting it to 50% dry matter, and then adding 5% CaO (DM basis). The "treated" corn stover must sit for at least one week before feeding to allow the chemical reaction to be effective. A common ration using this technology would include 20% treated corn stover and 40% wet DGS to replace 60% of the corn in a traditional feedlot diet. Results, however, have been somewhat variable (Russell et al., 2011; Shreck et al., 2012; Shreck et al., 2013b). In some cases, when cattle are fed treated corn stover performance is maintained (Russell et al., 2011; Chapple et al., 2013) or increased (Shreck et al., 2012) and digestibility is increased (Chapple et al., 2013; Duckworth et al., 2013; Shreck et al., 2013a) when compared to cattle fed corn-based diets. However, in other cases, feeding cattle treated corn stover diets reduced intakes and gains when compared to feeding similar diets where corn stover had not been treated with CaO (Duckworth et al., 2013). The process of treating corn stover is not without labor and effort; therefore, its effectiveness must be validated for this co-product to be successful in beef cattle rations.

The next new spin on corn co-products is "low fat". Of course, this again applies to DGS. Because of the differences in corn processing methods, fat concentration has not been an "issue" in CGF or CGM like it has in DGS, as the CGF and CGM contain fairly minimal concentrations of fat (NRC, 2000). Most of the oil is extracted from corn in the wet milling process, which yields CGF and CGM, and used for biofuel production (Atkinson et al., 2012) or other human needs. Much speculation surrounds the fat in DGS and whether it is "friend or foe". The elevated fat concentrations in traditional DGS were believed to be the primary factor increasing its energy value as the energy content in DGS comes from digestible fiber and fat instead of starch, as it does in corn (Schingoethe, 2004), even though the fat in DGS appears to be less digestible than fat from corn oil (Klopfenstein et al., 2008). Now, there is interest from the ethanol plants to extract excess oil from DGS, either via centrifugation or chemical solvents, in an effort to make retain more corn value.

What does this mean for beef cattle producers and nutritionists? As mentioned previously, fat in DGS varied plant to plant but according to the NRC (2000) was typically around 10 to 11%. The newer, low fat DGS will also vary and may contain 5 to 8% fat (Atkinson et al., 2012; Dicostanzo and Crawford, 2013). Atkinson et al. (2012) concluded that low fat DGS could be fed to beef cattle at 40 or up to 70% of the dietary DM inclusion without adversely impacting animal performance, as measured by ADG and feed efficiency, or carcass quality when compared to cattle fed a corn-based control. However, when cattle fed low fat DGS are compared to those fed normal DGS, performance is altered. Cattle fed low fat wet DGS (4.72% total dietary fat, DM basis) gained less than those fed normal fat wet DGS (6.91% total dietary fat, DM basis), even though their gain was still comparable to cattle fed a corn-based control (Gigax et al., 2011). These authors concluded that this does in fact suggest that removing the fat from DGS does lower its energy value. In a similar study, at similar dietary inclusion of DGS (35% DM basis), however, Kelzer et al. (2011) found no difference in gain between cattle fed low or normal fat dry DGS (3.53 and 5.96% total dietary fat, DM basis, respectively). While the two studies differed somewhat in CP and mineral concentrations, these factors likely contribute little to the energy value and, therefore, the difference between dry and wet low fat DGS may warrant further investigation. Just as with the traditional DGS, an analysis of the "new" DGS would be a good place to start.

Conclusions

Despite the fact that research on corn co-products has been going on for a number of decades, new information on these products continues to emerge. The key for beef cattle producers and nutritionists alike will be to stay on top of this new information. Most importantly, however, is to remember that these products, although referred to as "co-products" are secondary to the plants processing of corn for human consumption needs and fuel. Therefore, the composition of these corn co-products should always be determined before decisions regarding which co-products to use in the ration and at what dietary level they will be included are made.

Just as it had in the past, cost will, and should, continue to drive much of the decisions regarding "optimum" inclusion of co-products in beef rations. A lot of discussion surrounding distance from the plant was used to dominate the decisions between including wet and dry co-products in the rations. While shipping will continue to be part of the discussion, as corn co-products evolve, storing, handling, and feasibility issues will all have to be revisited. As is typical, these decisions will have to been made quickly to take advantage of opportunities as they arise and the need for rapid dissemination of new information on co-products will be paramount.

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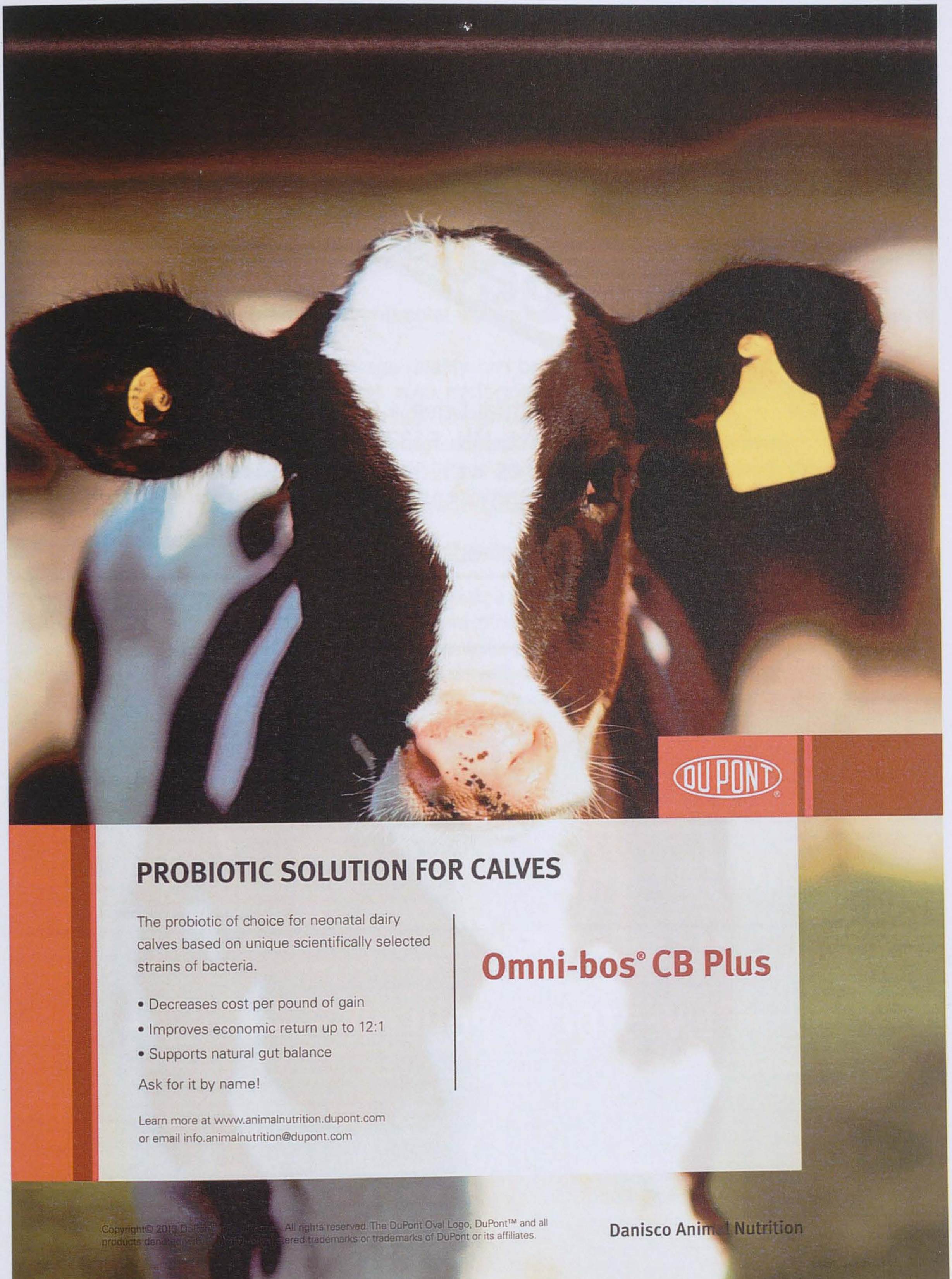
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