

## Feed Additives in Beef Cow Nutrition

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### Introduction

Feed additives have been defined as nonnutritive substances (i.e., substances other than known nutrients) added to feeds to improve the efficiency of feed utilization and feed acceptance, or to be beneficial to the health or metabolism of the animal (Cheeke, 1999). Cheeke (1999) classified feed additives as: I) additives that influence feed stability, feed manufacturing, and properties of feeds (e.g., antifungals, antioxidants, pellet binders); II) animal growth modifiers (e.g., intake, digestion, and/or metabolism modifiers and growth promotants); III) animal health modifiers (e.g., drugs, immunomodulators); and IV) additives that modify consumer acceptance (xanthophylls, saponins). While one potential method to reduce feed costs is through the use of feed additives, few of these additives have been tested in grazing animals, especially for cow/calf producers.

Profitability of any cow/calf operation depends on high pregnancy rates and low feed costs. Data has shown that body condition of cows at calving and breeding plays an important role in length of the postpartum interval and conception rate. While feed additives have long been used to improve feed efficiency and/or daily gain and control coccidiosis and liver abscesses in confined (e.g., feedlot) animals, much less research has been conducted with feed additives in grazing situations for cow/calf or stocker operations. With increased awareness of the importance of having adequate body condition on cows during the breeding season, the use of feed additives as a way of improving nutrient utilization in beef cows is of interest. Based on the limited available literature, this paper focuses on the role feed additives might play in improving production efficiency for cow/calf operations.

### *Direct-Fed Microbials*

Direct fed microbials (**DFM**), also referred to as probiotics, are live, naturally occurring supplements fed to livestock to enhance health and performance (Yoon and Stern, 1995; Beauchemin et al., 2006). Direct fed microbials is the name given to this class of feed additives by the FDA in 1989, and includes bacteria, fungi, and yeasts. Historical information pertaining to the use of DFM recently has been summarized by Beauchemin et al. (2006). Although these products have been classified by FDA, their use is currently not regulated. Producers should be aware that available commercial DFM products could include both viable and non-viable DFM. Most experiments evaluating DFM have been conducted with animals fed predominantly concentrate diets in confinement (dairies and/or feedlots). Information relative to the influence of DFM on grazing beef cattle is lacking.

Responses observed when feeding DFM have been variable. Primary actions of DFM are proposed to be: minimizing the growth of pathogenic bacteria; increasing desirable microbial populations in the gut; facilitating fiber digestion; and inactivating toxins (Dhuyvetter et al., 1995). Fungi (e.g., *Aspergillus oryzae*) and yeast (e.g., *Saccharomyces cerevisiae*) and their fermentation products are two DFM which have been evaluated in ruminants fed high-forage diets. *Aspergillus oryzae* is an aerobic culture that produces a wide variety fiber degrading enzymes including cellulases, hemicellulases, and esterases (Roper and Fennel, 1965). *Aspergillus oryzae* is produced from a selected strain of enzyme-producing *Aspergillus*. *Saccharomyces cerevisiae* is produced by fermenting cereal grain and selected raw ingredients with bakers yeast, and functions in an anaerobic environment. Although anaerobic, *S. cerevisiae* has not been specifically shown to hydrolyze fiber in the rumen. Through different means (aerobic vs. anaerobic), both cultures may produce a similar response of increasing the population of anaerobic and cellulolytic bacteria in the rumen (Newbold et al., 1991; Martin and Nisbet, 1992; Wallace and Newbold, 1992), which could potentially result in greater microbial activity and greater ruminal fermentation of fiber (Martin and Nisbet, 1992; Beharka and Nagaraja, 1993).

The addition of yeast (*S. cerevisiae*) to ruminal cultures has been shown to increase cellulose degradation in vitro (Dawson and Hopkins, 1991; Williams et al., 1991; Wohlt et al., 1991), and increase dry matter intake (**DMI**; Phillips and Von Tungeln, 1985; Hughes, 1988; Williams et al., 1991), average daily gain (**ADG**; Phillips and Von Tungeln, 1985; Fallon and Harte, 1987; McLeod et al., 1991) and feed efficiency (Hudyma and Grey, 1990) in concentrate-fed beef and dairy cattle. Increased DMI and ADG in concentrate-fed ruminants, as well as increased cellulose digestion, suggest that yeast may also benefit cattle grazing rangelands. Olson et al. (1994a,b) conducted an experiment to determine the influence of yeast cultures and advancing forage maturity on ruminal fermentation, site of digestion, and microbial protein synthesis in yearling beef steers grazing mixed-grass prairie from late June to early November in North Dakota. Treatments were control and yeast culture supplementation (28.4 gAster<sup>-1</sup>Ad<sup>-1</sup> dosed ruminally). Diet samples collected from the rumens of yeast culture-supplemented steers had greater soluble N and in vitro OM disappearance than diet samples from controls throughout the grazing season. Organic matter intake was greater by yeast culture-supplemented steers during June. In addition, increases in in situ NDF and CP disappearance were noted at various time points in forage samples collected in June, July, and August for the yeast-culture treatment group. Similarly, supplementation with yeast culture increased true ruminal OM digestion in late June and late July, and steers receiving yeast culture had greater duodenal bacterial N flow in late July. Therefore, increased digestibility associated with yeast-culture supplementation generally corresponded to sampling periods when forage CP was higher. As the season advanced and forage quality began to decline, ruminal fluid volume increased, true ruminal OM digestion decreased, and the ruminal microbes became more efficient (Olson et al., 1994a,b). During these periods, yeast supplementation was less efficacious.

Much of the eastern and southern United States has endophyte-infected fescue as the main source of forage energy and protein. While new varieties of endophyte-free

fescue continue to emerge, discovering management tools to improve utilization of existing fescue is still of interest. Yeast products might be one alternative for improving forage utilization. Williams (1986) showed improved weight gains by cattle grazing fescue pasture and supplemented with yeast culture. Yeast cultures have also been shown to decrease rectal temperatures during summer heat stress in dairy cattle (Harris and Lobo, 1988; Higginbotham et al., 1994). Both mineral consumption and absorption have been positively affected by the addition of yeast culture to free-choice mineral mixes (Higginbotham et al., 1994).

Boyles et al. (1999) conducted an experiment to evaluate the effect of yeast on cattle performance in fescue-based forage systems. Forty Angus and Angus-Hereford artificially inseminated heifers (761 " 60.2 lb) were used to evaluate the use of yeast-mineral mixes for grazing cattle. The grazing site was predominantly unimproved Kentucky-31 tall fescue, some red clover, orchardgrass, and brome grass present, but not seeded. Forage management was typical of the region. Twenty heifers were fed a mineral-containing yeast (Yeast) supplement, and the remaining 20 received a mineral supplement without yeast (Control). The Control supplement contained 12% Ca, 7% P, 23% salt, 4% Mg, 1% K, 1,000 ppm Cu, 4,000 ppm Zn, and 26 ppm Se, and the base mineral mix was similar for both supplements. Yeast was added to the base mineral at a rate of 25%. Both yeast and control supplements were available free-choice. Supplements were weighed into standard mineral feeders. Interim weights were obtained on cows (first-calf heifers) and calves at approximately 36 day intervals. All lactating heifers were evaluated for milk production approximately 60 and 120 days after calving using a weigh-suckle-weigh procedure. Calves were removed from the cows and only allowed access to their dams at eight-hour intervals during a 24-hour period. Calves were weighed immediately prior to and after suckling.

Yeast inclusion increased total mineral supplemental intake (Boyles et al., 1999). Total supplemental mineral intake was 0.23 and 0.40 lb/day for the control and yeast-mineral, respectively. The yeast-mineral intake was 4.8 ounces/day, and the total yeast consumption/day was 1.2 ounces. The difference in total supplement intake between treatments was 0.19 " 0.072 lb/day. Gestating heifers gained approximately 5 lb/month more weight if they had access to a free-choice mineral supplement containing yeast than the control mineral. In addition, yeast-supplemented heifers gained 9.1 lb/month more weight compared with controls during early-spring grass growth (April through June). In contrast, Control heifers lost less weight (12.8 lb/month) during the interval from calving (February) to peak lactation (April) compared with Yeast heifers. Milk production in May was 15.4 and 15.6 lb per day for control and yeast-supplemented heifers, respectively. However, milk production for heifers consuming the yeast-mineral mix was greater in August (12.9 vs. 9.6 lb/day). Weaning weights were improved (27 lb) by availability of a yeast-mineral mix. Although results are inconsistent, these data and results by Olson et al. (1994a,b) suggest that yeast products (*S. cerevisiae*) may assist in digestion of forages and increase performance.

Similar to yeast, previous research has not clearly delineated the potential value of fungal extracts in forage-based diets. In a study by Varel and Kreikemeier (1994), A.

*oryzae* (Amaferm, Biozyme, Inc.) had no effect on in situ degradation of bromegrass or alfalfa fiber fractions, with the exception of numerical differences between 3 and 12 h in which *A. oryzae* increased the degradation of the bromegrass hemicellulose fraction. Similarly, *A. oryzae* increased the degradation of bromegrass and switchgrass at 12 h, but not at 24 h in vitro (Varel et al., 1993). Beharka and Nagaraja (1993) found differences with *A. oryzae* in its ability to increase fiber degradation with various forages in vitro. Their results indicated that *A. oryzae* at 0.8 and 1.2 g/L increased degradation of NDF and ADF in bromegrass and alfalfa hay, but had no effect on degradability of NDF or ADF in pure cellulose, low-endophyte fescue, wheat straw, corn silage, or prairie hay. In vivo, Caton et al. (1993) found ruminal and total tract NDF and ADF digestibilities to be lower in steers grazing predominantly bromegrass pastures when supplemented with *A. oryzae* during June, but to be greater during July. Other studies have indicated that *A. oryzae* does not affect fiber digestion (Firkins et al., 1990; Oellermann et al., 1990). Because of these variable results, more studies are needed.

Several studies have indicated that *A. oryzae* increases the number of total ruminal bacteria (Frumholtz et al., 1989; Martin and Nisbet, 1992; Newbold et al., 1992b). In the study by Varel and Kreikemeier (1994), *A. oryzae* increased the total number of bacteria in cows fed bromegrass, but not in cows fed alfalfa. The number of cellulolytic bacteria was not affected by *A. oryzae* when alfalfa or brome hay was fed, although the number of cellulolytic *Ruminococcus albus* isolates were greater when *A. oryzae* was included in the bromegrass diet. Beharka and Nagaraja (1991) also reported an increased growth rate of *R. albus* and *Fibrobacter succinogenes* with the addition of *A. oryzae*. Other studies have reported an increase in the ruminal cellulolytic populations with *A. oryzae* (Wiedmeier et al., 1987; Newbold et al., 1991). In in vitro studies with bromegrass NDF as substrate, *A. oryzae* filtrate (8 %) increased numbers of both total anaerobic and cellulolytic microorganisms (Varel et al., 1993).

Gomez-Alarcon et al. (1990) and Caton et al. (1993) reported increased feed intake with *A. oryzae* supplementation. In contrast, *A. oryzae* had no effect on feed intake when bromegrass or alfalfa hay was fed (Varel and Kreikemeier, 1994). *Aspergillus oryzae* increased total anaerobic bacterial counts, but duodenal flow of microbial protein and microbial efficiency were lower (Varel and Kreikemeier, 1994). Therefore, although *A. oryzae* increased the total number of ruminal anaerobes, the authors were not able to measure an improvement in forage utilization or microbial protein synthesis.

Much of the prior work with DFM has focused on improving feed efficiency in feedlot cattle and milk production in dairy cattle (Beauchemin et al., 2006). Fewer studies have investigated the effects of DFM when used in high roughage diets and in particular, when fed in combination with an ionophore. Dhuyvetter et al. (1995) used 84 Charolais crossbred heifers (571.4 " 5.4 lb) to determine the effects of bambarmycins (Gainpro) and *A. oryzae* (Amaferm) on calf performance when fed in a high-forage grower diet. Treatments were: 1) no bambarmycins + no *A. oryzae* (Control); 2) 20 milligrams/head/day of bambarmycins; 3) 2 grams/head/day *A. oryzae*; or 4) 20 milligrams/head/day of bambarmycins and 2 grams/head/day *A. oryzae*. Treatments were formulated and delivered in a protein supplement comprised of soybean meal and

sunflower meal fed daily (0.86 lb/hd). Heifers were fed a corn-silage and oat hay based growing ration (63% of diet, DM basis) formulated for 2 lb ADG. There were no treatment interactions for heifer performance. Total ADG was improved 5.1% for Amaferm and 6.0% for Gainpro compared with heifers that did not receive these feed additives. Feed efficiency was also improved by 6.0% for Amaferm and 6.2% for Gainpro fed heifers. Heifers that were fed both feed additives had higher daily gains and were the most efficient in feed conversion when compared with all other treatments. Results indicated that both Amaferm and Gainpro had a positive effect on heifer growth when fed with high forage-based growing diets. When both feed additives were combined, heifer gain and feed conversions were further increased. The authors (Dhuyvetter et al., 1995) indicated that performance benefits for heifers used in this study would have paid for the feed additives and increased producer returns. Dietary additions of DFM in conjunction with ionophores or antibiotics may warrant further investigations for improving cow/calf performance and economic returns to cow/calf producers.

### ***Ionophores***

Ionophores are a class of antibiotics that are extensively used as a feed additive for cattle. Their name is derived from their mode of action. Ionophores serve as a carrier for transporting metal ions across cell membranes. The major ionophores fed to cattle are Rumensin (Elanco Animal Health, Greenfield, IN), Lasalocid (Bovatec, Alpharma, Fort Lee, NJ), and GainPro (bambermycins; Intervet, Millsboro, DE). Ionophores have long been used to increase performance (ADG and feed efficiency) and control bloat and coccidiosis in feedlot animals, which has led to their increased use in grazing situations for cow-calf and stocker operations. Rumensin is the only ionophore approved for use in reproducing beef cows (Thomas, 1999).

Ionophores change the ruminal microflora and the relative amounts of volatile fatty acids produced. In general, acetate, butyrate, lactate and formate concentrations are decreased, and the relative amount of propionate produced increases during the fermentation of feed in the rumen. The increased propionate to acetate ratio increases the amount of energy available to the animal for growth and other productive purposes (e.g., reproduction). In order to achieve a short postpartum interval and high conception rate in beef cows, adequate energy consumption is needed. Feeding Rumensin can help meet this energy need. In an effort to manage body condition score (**BCS**) in the cow herd, Thomas (1999) described "critical periods" during which feeding of supplemental energy may be essential. Because Rumensin increases the energy available from the diet, Rumensin could be added to the supplemental feed as an economical source of boosting energy available from the diet. The Acritical periods@ discussed were the last third of gestation, through the postpartum interval, and into the breeding season for mature cows. During each of these periods, thin cows (BCS below 5.0) could be sorted and fed additional energy along with Rumensin to obtain a BCS of 5.0 or higher. Following breeding, Rumensin can be removed depending upon the availability and quality of forage. Good management of BCS results in improved conception rates and heavier calves at weaning. Randel (1983) reported that beef cows fed rumensin from 256 days of pregnancy through the 12th week of lactation had a 12.4% increase in feed efficiency of

hay consumed. In addition, cows fed Rumensin had shorter intervals from calving to first estrus.

Factors which have been shown to influence the onset of puberty in replacement heifers include body size and condition, prepubertal growth rate, growth hormone, insulin, luteinizing hormone, and propionic acid (Moseley et al., 1977; McCartor et al., 1979, Randel et al., 1982). Granger et al. (1990) summarized 10 experiments which showed an average increase in ADG of 0.14 lb/day when Rumensin was fed to beef heifers. Others (Moseley et al., 1977; McCartor et al., 1979, Meinert et al., 1992) have shown that heifers fed Rumensin reached puberty and first estrus from 10 to 21 days sooner than non-supplemented controls. Increased growth rate and earlier onset of puberty can help heifers calve by two years of age.

As indicated, Rumensin provides additional energy to the animal through manipulation of ruminal fermentation (increased propionate:acetate; Randel et al., 1982). In growing animals, the additional energy derived from feeding 200 mg Rumensin daily has been calculated to be equivalent to a minimum of 1.0 lb of corn grain (Randel et al., 1982; Thomas, 1999). Feeding 1.0 lb corn grain (approximately 5.0 cents/day) compared with 200 mg of Rumensin (approximately 0.70 cents/day) indicates that inclusion of Rumensin into the feeding program of the cow herd may represent a cost savings during times when forage availability is inadequate or greater dietary energy is needed to meet the cow's energy demands. In addition, use of Rumensin in a replacement heifer program can increase ADG in addition to enhancing onset of puberty and pregnancy.

### ***Beta Agonists***

Livestock, including beef cattle, fed beta-agonists are known to have increased total carcass muscle or lean and decreased levels of carcass fat (lipid; Mersmann, 1998). The mechanism(s) that control these observed changes appear to be very complex; however, Koohmaraie et al. (1991) suggested that beta-agonists influence muscle hypertrophy rather than hyperplasia, and the fractional rate of protein degradation is slowed allowing for an increase in muscle protein synthesis. Carcass lean and rib-eye area was increased among Fresian steers fed a beta-agonist compound (Chikhou et al., 1993).

Feeding cows culled from the breeding herd prior to slaughter is a common practice. Apple (1999) showed that cows with a higher BCS and heavier body weight had both a higher carcass and live value and thus optimized economic return. Cull beef cows fed at least 28 days had carcasses with improved longissimus muscle marbling and quality grades, lower Warner-Bratzler shear force values (more tender), and improved sensory panel traits (Cranwell et al., 1996b). Cows fed for at least 56 days produced carcasses that also had improved visual lean color, texture, and firmness, as well as improved carcass fat color (Cranwell et al., 1996b). Cranwell et al. (1996a) further concluded that cows on full feed for at least 28 or 56 days had higher carcass weights due to an increase in both carcass lean and carcass fat.

Recently, the Food and Drug Administration has approved a beta-agonist (OptaflexxJ 45; Ractopamine HCl; Elanco Animal Health, Greenfield, IN) for use in feedlot cattle to increase lean meat yield when fed during the final 28 to 42 days of feeding. While data has been summarized from feeding trials with finishing steers and heifers, no data have been published with regard to feeding the same compound to cull cows. This class of animals plays an important role in the United States, providing valuable meat products. Carter et al. (2006) conducted an experiment to determine the effects of feeding a beta-agonist to cull cows on animal performance, lean meat yield, and carcass quality, as well as the economic viability of feeding cull cows in Florida. Ninety-two crossbred beef cows (11 yr " 1.8; initial BCS = 4.2 " 0.3) were fed in a 2 x 2 randomized complete block design with dietary treatment and implant (trenbolone acetate plus estradiol) status as factors. One-half of all cows were fed only the basal diet (CON) for 90 days; the remainder received CON for the first 55 days, then a beta-agonist (200 mg  $\text{hd}^{-1}\text{d}^{-1}$ ) was added for the last 35 days. The basal diet consisted primarily of soybean hulls, citrus pulp, cracked corn, wheat middlings, and cottonseed hulls and contained 87.6% DM, 14% CP (DM basis), and 79.5% TDN. Body weight and BCS were obtained on days 0, 54, and 90. Carcasses were harvested on day 92 and carcass data were collected. Final body weight and BCS did not differ by treatment; ADG and total gain tended to be increased (1.3 vs. 1.2 kg/d and 117.9 vs. 105.5 kg, respectively) for cows fed the beta-agonist. Among carcass yield measurements, the beta-agonist tended to increase hot carcass weight; no other carcass yield or quality results were different. Carcass value was not significantly different due to treatment; however, carcass value was increased \$248.09 when cows were fed for 90 days compared with selling cows thin on day 0. Although carcass quality was not adversely affected when cows were fed the beta-agonist additive, no significant improvement in animal performance or carcass yield was observed.

### **Conclusions**

Data on use of feed additives for cow/calf production are limited. Data in steers grazing mixed-grass prairie indicated that yeast-culture supplementation can increase true OM digestibility early in the grazing season, when forage quality is high. Although data are limited, one experiment showed increased growth rates of gestating heifers, increased milk production after parturition, and increased calf weaning weights when supplemental yeast was fed. Results with fungal cultures have shown similar, but inconsistent results. Ionophores can be added to the supplemental feed as an economical source of boosting energy available from the diet. During critical periods of the mature cow=s production cycle, Rumensin can help maintain adequate body condition to shorten postpartum interval and increase conception rates. In addition, use of Rumensin in a replacement heifer program can increase ADG in addition to enhancing onset of puberty and pregnancy. Improvements in meat volume and quality among fed cows has been observed and documented in literature. Inclusion of a dietary compound that can improve the carcass yield and quality could improve both the volume of marketable meat products coming from salvage cows as well as provide additional lean meat products for various consumer sectors (food service or retail). Feeding cows can also spread marketing to periods of the year that might be more economically advantageous. More

research is needed to determine if beta-agonists are effective for increasing lean-meat yield in cull cows.

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