EFFECTS OF CORNSTALK MAXIMIZER ON COW PERFORMANCE AND REPRODUCTION AS WELL AS CALF PERFORMANCE AND HEALTH

BY

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THESIS

Submitted in partial fulfillment of the requirements for the degree of Master of Science in Animal Sciences in the Graduate College of the University of Illinois at Urbana-Champaign, 2017

Urbana, Illinois

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ABSTRACT

Mature Simmental × Angus cows (n=96; 693±7.7 kg) were utilized to evaluate the effects of Cornstalk Calving Maximizer TMR® (CSMAX; US Feeds; Eldora, IA) supplement on cow/calf performance, reproduction, and health in a drylot system. Cows were blocked by age and calving date and assigned to one of 12 pens (8 cows·pen⁻¹). Pens were randomly assigned to one of two treatments which were provided from calving through breeding: control (CON; 0.30 kg·cow⁻¹·d⁻¹ wheat midds-based supplement including inorganic trace minerals, n=6) or CSMAX [0.30 kg·cow⁻¹·d⁻¹ of a wheat midds based supplement including: Cu, Zn, Mn, and Co as Bioplex® and Se as Selplex 2000®, 10 g·cow⁻¹·d⁻¹ Intergral A+®, 10 g·cow⁻¹·d⁻¹ Bio-Mos®, and 8 g·cow⁻¹·d⁻¹ Fibrozyme®; All technologies from Alltech, Nicholasville, KY; n=6]. Cow BW and BCS were determined post-calving, breeding, and weaning. Following AI (86±17 d postpartum), bulls were turned out for a 47 d breeding season and cattle were managed as a common group. There was a difference in cow BW at trial initiation (P = 0.05). Cow/calf BW and cow BCS did not differ (P ≥ 0.10) at any other time. Cows supplemented CSMAX tended (P = 0.07) to lose less BW through the supplementation period. Additionally, CSMAX improved diet digestibility (P < 0.01; CSMAX=70%, CON=63%). No differences in AI conception (P = 0.82; CSMAX=68.1% and CON=64.5%), overall pregnancy rate (P = 0.78), or cow/calf health parameters (P ≥ 0.10) were observed. Thus, supplementing drylot, lactating beef cows CSMAX improved dry matter digestibility which tended to decrease weight loss post-partum but this did not translate into an improvement in reproduction.

Keywords: Bio-Mos®, chelated trace minerals, Cow-calf, fibrozyme®, Intergral A+®
ACKNOWLEDGMENTS

To my wife, you have continuously supported me through my decision to pursue a masters and have made great sacrifices to be here with me. I will forever be thankful for you encouragement and positive attitude towards my education. To my parents, without your continued guidance and sound advice I would not be able to accomplish my lofty goals. You have instilled great knowledge and work ethic in me. I will always appreciate your financial support it has allowed me to chase my dreams.

To my fellow graduate students: Dr. Chris Cassady, Jack Oattes, Chance Meteer, Blake Lehman, Jordan Rauch, Becca Stokes, Dr. Bain Wilson, Lindsay Shoup, Chloe Long, Alyssa Clements, Brady Klatt, David Crawford, Pedro Carvalho, Sam Kneeskern, Dr. Josh McCann, Bailey Edenburn, Tiago Brandao, and Maddie Stierwalt, your contributions to data collection, lab work, data analysis and most of all your friendship has made this thesis possible.

To my advisors, Dr. Dan Shike, for having faith in me to coach the livestock judging team and pursue my masters. You have provided me with great guidance, direction and most of all friendship that has made my time here great. To Dr. Doug Parrett, your guidance “outside the office” has been enjoyable and certainly has allowed me to keep my sanity.
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CHAPTER 1

LITERATURE REVIEW

INTRODUCTION

Up to 63% of the total annual costs associated with a beef cow calf enterprise can be associated with feeding the cow herd (Miller et al., 2001). Lactating cows in the upper Midwest are often cared for during winter in dry lot conditions. However, increased forage prices and elevated trucking costs have resulted in producers looking for alternative forage sources in the Midwest. Thus, the implementation of corn stalks as a major portion of the diet has grown in popularity among beef cow calf enterprises. Braungardt et al. (2010) investigated feeding alfalfa hay versus corn residue bales supplemented with corn co-products to try and identify the cost effective winter cow rations and their effects on cow performance. And observed that low-quality roughage supplemented with DDGS was the more cost effective winter feeding method compared to feeding free choice hay. Shike et al. (2009) concluded that cornstalks supplemented with high levels of co-products (up to 75% of the diet) could effectively maintain cow weight, milk production, and reproduction in lactating mature cows.

Although corn stalk residue is widely available in the Midwest and can reduce the cost of beef cattle diets without impacting performance, there are some considerations related to feed delivery and harvest that can add to the cost. Limiting waste is an issue with feeding cornstalk bales as many producers grind the bales and feed a Total Mixed Ration (TMR). Processing stalk bales and obtaining the equipment to feed a TMR adds substantial overhead costs to an operation. Additional costs coupled with the potential for rapid spread of diseases that are associated with drylot feeding cows (Anderson and Boyles, 2007) has led to a push for new and
innovative technologies to maximize the production efficiency and mitigate potential challenges that lactating beef cattle are faced with in the upper Midwest.

**MANNAN OLigosaccharides**

Calf health status and nutrition post-partum is crucial to the long-term success of a calf. In most beef cattle enterprises, the use of antibiotics is the most common method to prevent or mitigate health problems. However, new legislation has regulated the use of feed grade antibiotics which has led to the adoption of alternative sources to antibiotics such as prebiotics. The definition of a prebiotic was summarized by Zhao et al. (2012) and Gibson et al. (2007) as any indigestible food ingredient that increases bacterial growth in the digestive system. Furthermore, mannann oligosaccharides (MOS) are prebiotics comprised of mannose sugars from a yeast cell wall that reduces pathogens in the gastrointestinal tract and enhances innate and humoral immunity. (Che et al., 2011).

In recent years there has been an influx of yeast products that have come onto the market. One MOS called Bio-Mos® (Alltech, Inc., Nicholasville, KY) is formulated from the cell wall of *Saccharomyces cerevisiae*. Many gram-negative bacteria attach to the intestinal epithelium using mannose-specific fimbriae, MOS provides more attractive binding sites for intestinal pathogens (Ofek et al., 1977). As a result of MOS being indigestible, bacteria bound to the MOS cell likely exit the intestine without attaching to the epithelium (Spring et al., 2000).

Bio-Mos has been studied in a variety of species including poultry, swine, and cattle. Yet, the majority of research on cattle have been based around the dairy industry and more specifically on Holstein and Jersey calves. Heinrichs et al. (2003) compared supplementing Bio-Mos in milk replacer at a rate of 4 g/d with an antibiotic supplemented milk replacer and a
control milk replacer with no additives on Holstein calves. When compared with the control, Bio-mos decreased the event of calf scours which led to an increase in feed intake at six weeks of age. Additionally, there were no significant differences in performance when compared to antibiotic supplemented milk replacer. Thus, authors concluded that Bio-Mos could serve as a replacement for antibiotics. However, Morrison et al. (2010) included Bio-Mos in Milk replacer to Holstein calves at a higher rate of 10 g/d and compared it to control without an antibiotic. As hypothesized, feed intake did increase at four weeks of age for Bio-mos supplemented calves, yet, this did not have an effect on live weight nor a decline in the number of scour episodes in the Bio-Mos treatments. A study completed by Franklin et al. (2005) evaluated the benefits of MOS supplementation to cows in the last three weeks of gestation on immune function of the cows and the subsequent transfer of passive immunity to their calves. They compared a control diet against Bio-Mos supplemented diet at 10 g/d in a TMR on Holstein and Jersey cow-calf pairs (39 cows and 41 calves). There were no treatment effects on cow body weight, white blood cell count, the level of total IgG in the blood, or the amount of colostrum produced. There was no treatment effect on calf birth weight or packed cell volume. Yet, there was a tendency for increases in serum protein concentration in calves from cows with MOS compared to cows fed control diet. The authors suggested this may allow for better transfer of passive immunity for cows fed the MOS. A study conducted by Linneen et al. (2014) evaluated the efficacy of Bio-Mos on beef cow performance and calf immunity when supplemented from late gestation through 30 d of lactation. Angus × Hereford cows (n=69) were supplemented a control diet or a control diet plus 10 g/d Bio-Mos. Bio-mos Cows tended to lose less BW and BCS from parturition through the end of the feeding period. However, there were no differences in any calf immunity parameters
measured. In conclusion, there is minimal and inconsistent evidence that Bio-Mos improves calf immunity or has an effect on cow performance variables.

EXOGENOUS ENZYMES

Digestion and breakdown of cell wall fractions in the rumen can be deemed as inefficient due to the complex linkage of the cell wall. Thus, in beef cattle production it is essential for producers to find technologies to maximize digestibility. In ruminant nutrition, enzymes are typically derived from fungal (*Trichoderma longibrachiatum, Aspergillus niger, and A. oryzae*) and bacterial (*Bacillus* spp., *Penicillium funiculosum*) sources (Beauchemin et al., 2004). These enzymes then can be applied to a diet in liquid or granular form. One justification for using exogenous enzymes for beef cattle is to aid in fiber digestion. Considering that total tract digestibility of NDF is usually below 50%, major production improvements in dry matter digestibility can be made (Vera et al., 2012). Responses to enzyme use have been highly variable due to differences in forage type and quality. Beauchemin et al. (2003) stated that effectiveness of enzyme additives can depend heavily on product formulation, dose rates, the composition of the targeted forage, and the method of providing enzyme additives. Glycosylation is a process that prevents degradation of the enzyme by rumen microorganisms. Variation in enzyme origin and form may be leading to inconsistent responses observed when enzymes are included in beef cattle diets (Mendoza et al., 2014).

The use of exogenous enzymes to improve beef cattle production parameters such as BW gain and feed digestibility have been noted since the 1960s (Beauchemin et al., 2006). Yet, the addition of these technologies to producers feeding programs has been very slow because the cost of the enzymes is more than of commercially available feed technologies such as ionophores, antibiotics, and implants (Beauchemin et al., 2006). Exogenous enzymes have been
most successful in high forage diets with multiple reports of improved fiber digestability. A study by Beauchemin et al. (1995) applied an exogenous enzyme to three forage-based diets (alfalfa hay, Timothy hay, and barley silage). Steers fed alfalfa and timothy hay with the enzyme had 30-36% greater when compared with the negative control. Yet, the enzyme had no effect when applied to barley silage. The authors hypothesized the increase in ADG to an increase in digestible DM intake. Vera et al. (2012) supplemented an enzyme (Danisco-Agtech, Waukesha, WI) during the growing phase of steers and they observed a 14.8% increase in DMI. Authors noted that the increase in passage rate reduced NDF digestibility (4.1%). No improvements in BW gain or feed efficiency were observed when this same enzyme was added to a finishing diet. Gómez-Vázquez et al. (2003) conducted an experiment to study the effects of fibrolytic enzymes Fibrozyme (Alltech, Inc.) on gain and digestibility of steers grazing stargrass and sugar cane plus urea. Supplementation of Fibrozyme (Alltech, Inc.) improved the live weight gain of steers grazing on African stargrass pastures, due to a higher intake of digestible nutrients from sugar cane. Adversely, Eun et al. (2009) applied an enzyme product Fibrozyme (Alltech, Inc.) to beef feedlot steer diets and this resulted in no effect on growth performance, despite minor improvements in carcass characteristics. A review of dietary supplementation of exogenous enzymes was noted by Beauchemin et al. (2003). They noted increases in dry matter intake and in milk yield. However, there have been inconsistent results regarding nutrient digestion, metabolism and performance of dairy cows when supplemented with exogenous enzymes (Beauchemin et al., 2000; Reddish and Kung, 2007; Arriola et al., 2011). The inconsistent results in beef cattle suggest that additional evidenced is need to determine if enzyme efficacy is dependent on forage type and delivery method.
TRACE MINERALS

Minerals can be classified in nutrition as macro or micro minerals. The macro minerals are needed in larger quantities, while micro or trace minerals are needed in smaller amounts but are essential for many biological functions. Trace mineral deficiency can decrease forage intake, reproductive efficiency, immune function, ADG, and gain to feed (Paterson and Engle, 2005). Trace minerals are also required for vitamin synthesis, hormone production, enzyme activity, collagen formation, tissue synthesis, oxygen transport, energy production, and other physiological processes related to growth, reproduction, and health. Cattle require 8 trace minerals: cobalt (Co), copper (Cu), iodide (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se) and zinc (Zn) (Hambidge, 2003). This thesis will focus on the trace minerals Cu, Mn, Se, and Zn because these are the trace minerals that were included in the experiment in chapter 2.

Copper

Copper requirements fluctuate based on the animal’s biological state and need for growth and reproduction (Spears, 2003), yet, the required set forth by the NRC (2016) is defined as 10 mg Cu/kg dietary DM for all beef cattle. Copper is absorbed in much lower quantities in ruminants than non-ruminants (Spears, 2003). Copper is extremely critical and serves as a vital component of many enzymes that have are involved in cellular respiration, cross-linking of connective tissue, central nervous system formation, and supports growth and immunity, as well as reproduction (NRC, 2016). Copper can influence reproductive success in many ways including the fact that copper modulates the activity of prostaglandin E2. It has also been (Barnea and Cho, 1987). Copper deficiency is commonly associated with early embryonic death as Cu has been found to be required in greater amounts during fetal development (Hidirogolu,
It has been long known that cows grazing Cu-deficient pastures can result in a delayed onset to estrus (Allcroft and Parker, 1949). A Cu deficiency is generally caused by intake of forages with high amounts of Cu antagonists such as Zn, Fe, and Mo (Spears, 2000). Additionally, it has been shown that when additional Mo is included in a diet to enhance the severity of Cu deficiency, decreases in growth have been observed (Phillippo et al., 1987). Gestational status can affect Cu absorption and retention as pregnant cattle have higher uptake and retention of Cu (Vierboom et al., 2003). Heifers were fed Cu-deficient diets in a study by Gengelbach (1994) and the subsequent calves were severely deficient in Cu prior to weaning and had reduced average daily gain.

Cu utilization has been shown to vary greatly among breeds. Gooneratne et al. (1994) observed that Simmental and Charolais cattle (Continental breeds) excrete more Cu in the urine and retain higher levels of blood plasma Cu compared with Angus cattle. Ultimately, it has been speculated that continental breeds of cattle have higher Cu requirements than British breeds such as Angus (Smart and Christensen, 1985; Gooneratne et al., 1994; Ward et al., 1995; Mullis et al., 2003).

Zinc

The recommended requirement of Zn in beef cattle diets is 30 mg of Zn/kg dietary DM (NRC, 2016). Zinc is an essential component of multiple enzymes including enzymes involved in the synthesis of DNA and RNA (Spears and Weiss, 2008). One of the first lines of defense the body has against an immunological attack, is the skin. Zinc has a critical role in maintaining the structural integrity of tissues, such as epithelial tissue (Larson, 2005). Additionally, Zn is essential in the uptake transport mechanism and utilization of vitamin A and E. However, animals do not have the ability to store Zn to make it readily available when in a deficient state.
Some signs of Zn deficiency include loss of appetite, a bowing of the hind legs, submucosal hemorrhages, unthrifty appearance, rough hair coats, dry scaly skin, and stiffness in the joints with swelling of the feet and joints (Paterson and Engle, 2005).

Spain et al. (1993) observed dairy cows supplemented with Zn had a decrease in infections of the mammary gland during lactation. While minimal research has evaluated Zn supplementation and its effects on a lactating beef cow, Hansard et al. (1968) indicated that as the fetus grows, Zn concentrations increase in bovine conception products (placenta, placental fluids, and fetus) in cattle. Proper Zn supplementation has been shown to have a positive impact on growing feeder cattle. Feeder cattle in times of stress are less susceptible to diseases when Zn is feed above NRC requirements (Nockels et al., 1993). Furthermore, Chirase et al. (1991) indicated that diets supplemented with Zn can enhance the recovery rate of IBR-stressed cattle.

**Manganese**

The Mn requirement is 20 mg/kg for growing and finishing cattle, but the greater amount of Mn needed for reproduction increases the requirement for breeding cattle to 40 mg/kg (NRC, 2016). This increased requirement for breeding cattle was demonstrated in 1965 by Rojas et al. were cows fed a diet containing 15.8 mg Mn/kg exhibited lower conception rates and longer calving seasons compared to control animals supplemented 25 mg Mn/kg. Mn plays an important role within the ovary in hormone synthesis where it stimulates cholesterol synthesis which indirectly influences steroid hormone synthesis (DiCostanzo et al., 1986). Ovarian follicles and CL of ewes absorbed a larger amount of radioactively labeled manganese than ovarian or extra-ovarian reproductive tissues, suggesting the accumulation of Mn within the CL and follicles is for the synthesis of hormones (Hidiroglou and Shearer, 1976).
Additional Mn supplementation has not shown significant results on cattle growth. In a study designed to test dietary levels of Mn on heifer growth and reproductive performance, supplemental levels (0, 10, 30, 50 mg/ Mn kg DM) added to a diet containing 15.8 mg of Mn/kg of diet DM did not affect ADG, dry matter intake or feed efficiency of heifers (Hansen et al., 2006). Based on the results, the authors hypothesized that 15.8 mg of Mn/kg of DM was sufficient to meet the heifers needs for growth (Hansen et al., 2006). Similarly, no effect on growth has also been seen in other trials investigating dietary levels of Mn in beef growing cattle (Bentley and Phillips, 1951; Legleiter et al., 2005).

*Selenium*

Se deficiency has been associated with abnormalities and diseases in ruminant animals, including white muscle disease, retained placenta, reduced growth rate, reduced reproduction rates, and immunosuppression. Deficiencies of Se in the soil are common in parts of the U.S. and result in forage that is also deficient. Cattle consuming those deficient forages often do not meet the dietary requirement. Deficiencies can lead to stiffness, lameness, cardiac failure, and white muscle disease in the offspring of these animals. Many factors including calcium, arsenic, cobalt, and sulfur can alter Se absorption. It is recommended that diets consumed by beef cattle at all stages of life (calves, heifers and lactating and dry cattle) should contain 0.10 mg Se/kg of diet and that the maximal amount of supplemental Se not exceed 5.0 mg/kg Se per day (NRC, 2016). Ruminant animals absorb less Se when compared to nonruminant’s due to the Se selenite forming insoluble complexes in the rumen (Wright and Bell, 1966). This is significant because minimal absorption happens in the rumen and most occurs in the duodenum (NRC, 2016). It was found that organic Se in the ruminant diet contributes to greater Se concentration in colostrum and milk. Additionally, organic Se seems to cross the ruminant placenta with greater efficiency.
than dietary inorganic forms (NRC, 2016). It was reported in dairy cattle fed a Se supplement, Sel-Plex (Alltech, Inc., Nicholasville, KY) had significantly higher milk Se content within 2 weeks of initiating supplementation than when sodium selenite was supplemented (McIntosh and Royle, 2002). In a meta-analysis by Ceballos et al., (2009) cows supplemented with Se yeast (6 g/h/d) had a greater increase in milk Se concentrations (0.37 μmol/L) when compared with those supplemented with inorganic forms of Se. This Se improvement may aid the function of the antioxidant system of newborn calves through the antioxidant activity of Se (Slavik et al., 2008). The efficiency of Se transfer to milk of cattle fed Se-yeast ranged from 9.9 to 12.5%, compared with 2.4-4.1% for cattle fed sodium selenite (Givens et al., 2004).

**Trace Mineral Absorption**

Historically, trace minerals have been supplemented to beef cattle in the inorganic form (Paterson et al., 1999). However, there is great variation in the bioavailability among mineral sources. This is a result of biochemical reactions that occur in the rumen which decreases the bioavailability to the animal (Spears, 2003). Furthermore, mineral in the forms of inorganic salts and oxide sources create the most indigestible complexes because of their high reactivity in the rumen. In contrast, chelated trace minerals are stable in the digestive tract because they are protected from forming complexes with other dietary components that inhibit absorption (Spears, 2003) allowing them to bypass the rumen and be utilized by the animal (Paterson et al., 1999).

In studies that have compared a chelate vs. inorganic mineral supplementation, authors have attributed increases in health and reproduction to greater absorption of chelated trace minerals. Swenson et al. (1998) evaluated the effects of supplemental TM form (organic vs. inorganic) fed in the presence of an antagonistic mineral element on first-calf heifer post-partum interval, milk production, and progeny performance with supplementation starting at either 30 or
Authors observed an increase in milk production, a decrease in the incidence of scours, and shorter post-partum intervals to the first estrus compared to unsupplemented heifers and heifers fed inorganic trace mineral supplement. Stanton et al. (2000) utilized 300 Angus cows in a 209 d trial that started prior to calving where cows were supplemented with three mineral treatments; a low-level inorganic mineral supplement, a high level of inorganic supplement, and a high-level organic supplement. Although no cow performance variables were affected, cattle in the organic mineral treatment exhibited greater AI conception rates than the other two inorganic treatments, despite no effect on overall pregnancy rates. Similarly, Ahola et al. (2004) conducted a study with crossbred cows (n=178) evaluating one of three treatments; a control with no mineral supplementation, a 100% inorganic mineral, and 50/50 mix of organic and inorganic mineral. In year 1 there was a trend for cows supplemented with the organic mineral mix to have a higher conception to AI (67% vs. 52%), yet, there were no differences in overall pregnancy rate. However, in year 2 (148 of the cows were retained in year 2) there were no differences in conception rates to AI. When both years of the trial were pooled, the indication was that the cattle provided the organic mix treatment tended to have better pregnancy rates to AI than the control cows or 100% inorganic mineral treatment. Vanegas et al. (2004) reported that injecting dairy cows with trace mineral solution before calving and before breeding resulted in decreased AI conception compared to cows injected with saline. Daugherty et al. (2002) injected beef cows with Cu, Zn, Mn, Se, and vitamin E and observed greater serum concentrations of Cu than untreated cows. Despite increased Cu status, there was no effect on conception rates of cows. Lamb et al. (2008) evaluated the effects of organic and inorganic TM supplements on follicular response, ovulation, and embryo production in super-ovulated Angus heifers. Treatments were initiated 23 d prior to embryo recovery with a
45-d adaptation period. The average numbers of recovered eggs and embryos were similar among treatments; however, the number of unfertilized eggs was greater for heifers receiving inorganic mineral than for heifers receiving organic mineral.

Improvements in trace mineral absorption associated with feeding chelated trace minerals have also shown benefits in improving hoof integrity. Bovine digital dermatitis (DD) is a contagious claw disease that leads to painful, ulcerative lesions of the skin line near the heel of the foot (Read and Walker, 1998). Previous research done in dairy heifers has shown that a diet supplemented with chelated trace minerals aids in the control of DD and a reduced size of active lesions (Gomez et al., 2014). Furthermore, Kulow et al. (2017) evaluated the prevalence of DD and the effects on performance in beef feedlot cattle (n=1077) supplemented with either a chelated trace mineral or a control inorganic supplement. Authors noted a significantly higher prevalence of DD in the control cattle. Additionally, growth performance, final live weight, and hot carcass weight were decreased when cattle were observed with a DD lesion.

**MYCOTOXINS**

Mycotoxins are natural molds produced by fungi growing on plants and they are in the form of filamentous fungi (Zain, 2011). Mold identification on a feedstuff can help producers know if they need to test the specific feed stuff for a high level of mycotoxins, but the presence of molds does not always indicate a high level of mycotoxins. Mycotoxins can be produced by a wide range of molds and are not essential to the mold's existence (Zain, 2011). The majority of mycotoxins can be formed on crops in the field, during harvest, or during storage, processing, or feeding (Dicostanzo et al., 1996). Mold growth and the production of mycotoxins are usually associated with extreme weather conditions, poor storage practices, and inadequate feeding conditions. The three molds *Aspergillus, Fusarium, and Penicillium* are the most prevalent in
producing mycotoxins which can have serious impacts on cattle (Dicostanzo et al., 1996). Cattle are generally resistant to the effect that mycotoxins can have on the animal because the rumen is typically able to degrade those compounds. However, when mycotoxin concentration is high, the rumen is unable to perform properly. Historic reports documented mycotoxin affecting 25% of crops annually (Jelinek, 1987). Although it is difficult to assess the economic impact of mycotoxins, it is generally agreed that the cost is substantial.

Specific mycotoxins produced by A. flavus are referred to as aflatoxins which is the major class of mycotoxins that will be discussed in this thesis. They are particularly important in this study because aflatoxins are typically associated with starchy feedstuffs like corn grown in warm and humid climates. However, in a drought-year like 1988 aflatoxins were estimated to be in 5% of corn grain in the Midwestern United States (Russell et al., 1991). Aflatoxin infiltration can affect vaccine-induced immunity and lower the resistance to diseases (Diekman and Green, 1992). In beef cattle, Garrett et al. (1968) observed decreased weight gain and feed intake in diets containing 700 ppb aflatoxin. Furthermore, detrimental effects in dairy cattle have been observed with diets that had as little as 120 ppb aflatoxin. Guthrie and Bedell (1979) noted that first service conception rate declined and the overall pregnancy rate was compromised, but when cows were moved to a minimal aflatoxin diet, milk production increased by 25%.

BINDERS

Feed additives such as antioxidants, AA, oligosaccharides, and adsorbents have been identified as a way to mitigate the effects of dietary mycotoxin inclusion. Some of the most common that are used in animal nutrition include aluminosilicates (clay, bentonite, montmorillonite, zeolite, phyllosilicates, etc.), complex indigestible carbohydrates (cell walls of yeast and bacteria), and synthetic polymers such as cholestyramine and polyvinylpyrrolidone. In
swine nutrition, the addition of a mycotoxin binder is said to be the best mitigation strategy when feeding high mycotoxin diets (Galvano et al., 2001). The proposed mechanism that binders use to prevent contamination is by binding the mycotoxin in the digestive tract and forming an indigestible complex that will not be absorbed by the animal and excreted in the feces.

The most popular mycotoxin mitigation strategy that has been adopted is the supplementation of a binder or absorbent because of their ease of use. One yeast product that is common added to beef cattle diets is Integral A+ (Alltech, Inc.) which is derived from the enzymatic hydrolysis of whole *Saccharomyces cerevisiae* cells. Fibrous material on the yeast cell wall was shown to have a potential to bind several mycotoxins (Devegowda et al., 1998). These yeast products have been shown to reduce the effects of aflatoxins in both broiler and rat diets (Stanley et al., 1993; Baptista et al., 2002). The addition of a yeast product to aflatoxin contaminated diets of dairy cows has significantly reduced milk aflatoxin residues (Diaz et al., 2004), but the same product failed to reduce milk aflatoxin in a subsequent study (Stroud, 2006). In conclusion, there is a potential for binders to help manage mycotoxin problems, but there have been variable results in in-vivo studies with cattle.

**SUMMARY**

Greater production costs, a challenging environment and the potential for rapid spread of diseases that are associated with drylot feeding cows (Anderson and Boyles, 2007) have led to a push for new and innovative technologies to maximize the production efficiency and mitigate potential challenges lactating beef cattle in the upper Midwest are faced with. With increased forage prices and elevated trucking costs, producers have looked for alternative forage sources in the Midwest. Thus, the implementation of corn stalks has become more popular due to limited availability of hay and the low cost of corn stalks.
Many technologies have shown improvements to beef cattle performance including a mannan oligosaccharide called Bio-Mos® (Alltech, Inc.). It has been reported that supplementation can decrease the incidence of scours in Holstein calves and decrease weight loss in beef cows postpartum. Additionally, the use of exogenous enzymes like Fibrozome (Alltech, Inc.) to improve beef cattle production parameters such as BW gain and feed digestibility have been noted since the 1960s. Furthermore, the inclusion of chelated trace minerals to beef cattle on low-quality forage diets has elicited improved reproductive success. Finally, with the potential for elevated levels of mycotoxins in baled cornstalks, the addition of the mycotoxin binder Integral A+ (Alltech, Inc.) to aflatoxin contaminated diets of dairy cows has significantly reduced milk aflatoxin residues. Many other technologies exist that could improve the performance of the lactating beef cow. Still, there is minimal research that has looked at the efficacy of a supplement that combined multiple technologies in an effort to target multiple critical control points in a beef cow enterprise. Identifying a complete supplement that can improve cow-calf performance could ultimately improve the bottom line of beef cattle enterprises in the Midwest.


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Chirase, N. K., D. P. Hutcheson, and G. B. Thompson. 1991. Feed intake, rectal temperature, and serum mineral concentrations of feedlot cattle fed zinc oxide or zinc methionine and


doi:10.1023/b:myco.0000020587.93872.59


CHAPTER 2

EFFECTS OF CORNSTALK MAXIMIZER ON COW PERFORMANCE AND REPRODUCTION AS WELL AS CALF PERFORMANCE AND HEALTH

ABSTRACT

Mature Simmental × Angus cows (n=96; 693±7.7 kg) were utilized to evaluate the effects of Cornstalk Calving Maximizer TMR® (CSMAX; US Feeds; Eldora, IA) supplement on cow/calf performance, reproduction, and health in a drylot system. Cows were blocked by age and calving date and assigned to one of 12 pens (8 cows·pen⁻¹). Pens were randomly assigned to one of two treatments which were provided from calving through breeding: control (CON; 0.30 kg·cow⁻¹·d⁻¹ wheat midds-based supplement including inorganic trace minerals, n=6) or CSMAX [0.30 kg·cow⁻¹·d⁻¹ of a wheat midds based supplement including: Cu, Zn, Mn, and Co as Bioplex® and Se as Selplex 2000®, 10 g·cow⁻¹·d⁻¹ Intergral A+®, 10 g·cow⁻¹·d⁻¹ Bio-Mos®, and 8 g·cow⁻¹·d⁻¹ Fibrozyme®; All technologies from Alltech, Nicholasville, KY; n=6]. Cow BW and BCS were determined post-calving, breeding, and weaning. Following AI (86±17 d postpartum), bulls were turned out for a 47 d breeding season and cattle were managed as a common group. There was a difference in cow BW at trial initiation (P = 0.05). Cow/calf BW and cow BCS did not differ (P ≥ 0.10) at any other time. Cows supplemented CSMAX tended (P = 0.07) to lose less BW through the supplementation period. Additionally, CSMAX improved diet digestibility (P < 0.01; CSMAX=70%, CON=63%). No differences in AI conception (P = 0.82; CSMAX=68.1% and CON=64.5%), overall pregnancy rate (P = 0.78), or cow/calf health parameters (P ≥ 0.10) were observed. Thus, supplementing drylot, lactating beef cows CSMAX improved dry matter digestibility which tended to decrease weight loss post-partum but this did not translate into an improvement in reproduction.

Keywords: Bio-Mos®, chelated trace minerals, Cow-calf, fibrozyme®, Intergral A+®
INTRODUCTION

Up to 63% of the total annual costs associated with a beef cow calf enterprise can be associated with feeding the cow herd (Miller et al., 2001). Lactating cows in the upper Midwest are often cared for during winter in dry lot conditions. However, increased forage prices and elevated trucking costs have resulted in a producer demand for alternative forage sources in the Midwest. Thus, the utilization of corn stalks as a major portion of the diet due to its availability and lower cost has gained popularity. However, additional costs associated with the more challenging environment and potential for rapid spread of diseases that are common with dry-lot feeding cows (Anderson and Boyles, 2007) has led to a push for new and innovative technologies to maximize production.

A mannan oligosaccharide (Bio-Mos®; Alltech, Inc., Nicholasville, KY) decreased the incidence of scours in Holstein calves (Heinrichs et al., 2003) and decreased weight loss in beef cows postpartum (Linneen et al., 2014). Additionally, the use of exogenous enzymes like Fibrozome® (Alltech, Inc., Nicholasville, KY) to improve beef cattle production parameters such as BW gain and feed digestibility have been noted since the 1960s. Beauchemin et al. (1995) applied an exogenous enzyme to a forage based diet and noted an increase in digestible DM intake. Furthermore, the inclusion of chelated trace minerals such as Bioplex® (Alltech, Inc.,) and Selplex 2000® (Alltech, Inc., Nicholasville, KY) to beef cattle on low-quality high forage diets has shown to increase reproductive success of beef cattle (Ahola et al., 2004; Swenson et al., 1998). Finally, with the potential for elevated levels of mycotoxins in bailed cornstalks, the addition of the mycotoxin binder Integral A+® (Alltech, Nicholasville, KY) to aflatoxin contaminated diets has significantly reduced milk aflatoxin residues (Diaz et al., 2004). Many other individual technologies exist that could improve the performance of the lactating
beef cow. Still, there is minimal research that has looked at the efficacy of a supplement that combined multiple technologies in beef cows fed cornstalk-based rations in dry-lot conditions.

Cornstalk Calving Maximizer TMR® (US Feeds, Eldora IA) is a supplement that combines multiple feed technologies with the goal of mitigating many of the issues associated with feeding low-quality forages. The objective of this study was to evaluate the effects of feeding Corn Stalk TMR Calving Maximizer® supplement from calving to breeding on cow performance, milk production, and subsequent reproduction as well as calf performance and health.

**MATERIALS AND METHODS**

Cattle were managed according to the guidelines recommended in the Guide for the Care and Use of Agriculture Animals in Agriculture Research and Teaching (FASS, 2010). All experimental procedures with animals were approved by the University of Illinois Institutional Animal Care and Use Committee.

*Animals and Experimental Design.*

To evaluate the effects of Cornstalk Calving Maximizer TMR® (CSMAX; US Feeds; Eldora, IA) supplement on beef cow performance and reproduction as well as calf performance and health, 96 spring-calving (calving date = 2/25/2015 ± 17d), Angus × Simmental cows (BW = 693 ± 7.7 kg) were fed for 86 d following calving at the Orr Agricultural Research and Demonstration Center in Baylis, IL. Cows received 0.30 kg DM·d⁻¹ of 1 of 2 treatments: Cornstalk Calving Maximizer TMR® (CSMAX; US Feeds; Eldora, IA) or Control [CON; US Feeds; Eldora, IA]. The CSMAX was a wheat midds based supplement including; chelated trace minerals (Cu, Zn, Mn, and Co as Bioplex® and Se as Selplex 2000®), 3% Intergral A⁺®
(provided 10 g·cow⁻¹·d⁻¹), 3% Bio-Mos® (provided 10 g·cow⁻¹·d⁻¹), and 2.35% Fibrozyme® (provided 8 g·cow⁻¹·d⁻¹); all technologies from Alltech, Nicholasville, KY. The CON was a wheat midds based supplement including inorganic trace minerals to meet or exceed NRC (2016) requirements. Cows were blocked by age and calving date and assigned to 12 pens after calving, with 8 cows per pen and 6 pens per treatment. Cows were maintained in 11.0- x 10.7-m concrete lots with a 7- x 7-m open-front shed. Each pen had a 7.3 m fence-line bunk. Treatments were applied via a TMR (Table 1). Rations were limit-fed at 12.7 kg·cow·d⁻¹ and included the following; 4.3 kg of corn silage, 5.2 kg corn stalks, 2.9 kg DDGS, and 0.30 kg of designated supplement.

Cows were evenly assigned to one of three 5 d CO-Synch + CIDR protocols as outlined by Grussing et al. (2016), and AI to one of three bulls (86 ± 17 d postpartum). Ten d following AI, cows were exposed to bulls for a 47 d breeding season. Conception to AI and overall pregnancy were determined at 40 d post-AI and 98 d post-AI, respectively. Conception to AI and overall pregnancy rates were determined by a trained technician via ultrasonography (Aloka 500 instrument (Wallingford, CT); 7.5 MHz general purpose transducer array).

Following the conclusion of the supplementation period, on May 21st, 2015 (86 ± 17 d postpartum), cow-calf pairs were commingled and managed as a common group on pasture and grazed red clover (Trifolium pretense), white clover (Trifolium repens), and endophyte-infected fescue (Festuca arundinacea) pastures (54.37% NDF, 30.06% ADF, and 15.38% CP) until weaning (183 ± 17 d postpartum). Cows had access to a free choice inorganic mineral (ORR Beef HI-MAG cattle mineral; Pike Feeds; Pittsfield, IL), formulated to meet or exceeds NRC requirement, from breeding/turnout (86 ± 17 d postpartum) until 106 ± 17 d postpartum. Then from 106 ± 17 d postpartum to weaning (184 ± 17 d postpartum) a free choice mineral
(Advantage Fescue Mineral CTC5600; US Feeds; Eldora, IA) containing chelated trace minerals (Bioplex®; Alltech, Inc.) was offered. Both free choice minerals were formulated to meet or exceed NRC (2016) requirements.

**Sample collection and analytical procedures.**

Cow BW and BCS [emaciated = 1; obese = 9; as described by Wagner et al. (1988)] were collected at the initiation of the trial (d 0), at initiation of synchronization (d 78 and d 79), and weaning (d 184). A single shrunk cow BW was recorded within 24 hours postpartum while d 78, d 79 and, d 184 weights were full weights taken prior to feeding. Calf birth weights were used as initial calf BW.

Milk production was estimated using the weigh-suckle-weigh (WSW) technique at 66 ± 17 d postpartum. Twenty-four hour milk production estimates were determined using a 12-hour WSW technique (Beal et al., 1990). Calf weight at WSW was used to calculate calf ADG.

Dry matter digestibility was determined in cows using the acid insoluble ash (AIA) procedure (Van Keulen and Young, 1977). Prior to individual fecal sampling, cow feed samples were taken for five consecutive days. Fecal samples were taken via rectal palpation 65 ± 17 d postpartum. Individual fecal and feed samples were then dried at 55° C for 3 d, and ground using a Wiley mill (1-mm screen, Arthur H. Thomas, Philadelphia, PA). Feed samples were composited and fecal samples were composited by pen. Five mg of feed and fecal samples were dried at 105° C for 24 hours. Samples were removed, cooled in a dessicator, and weighed.

Samples were then ashed (minimum 450° C for 9-12 hr; Thermolyte muffle oven Model F30420C, Thermo Scientific, Waltham, MA). Samples were removed and cooled in a dessicator. Ashed samples were placed in 500 ml Berzelius beakers, Pyrex #1040 (Corning Inc., Corning, NY) containing 100 ml of 2N HCl, and boiled for 5 min. All contents in the beakers were then
filtered through Watman #54 filter paper (hardened, ashless; Sigma-Aldrich Co. LLC; St. Louis, MO) and the beakers were rinsed with distilled water. The filter paper was then placed into an empty, pre-ashed crucible and ashed (minimum 450° C for 9-12 h; Thermo Scientific). Ashed samples were then weighed. Percent AIA in the feed and feces represented the proportion of sample that was not hydrolyzed by 2N HCl and not subsequently volatilized upon incineration of the acid insoluble residue. Percent dry matter digestibility was determined by dividing the percent AIA in the feed by the percent AIA in the feces, and multiplying this result by 100.

Feed samples were collected every two weeks for analysis during the feeding period. Individual feed ingredients were collected and composited and dried at 55° C for a minimum of 3 days and ground through a 1 mm screen using a Wiley mill (Arthur, H. Thomas, Philadelphia, PA) for nutrient composition analysis. Ground feed samples were analyzed for CP (Leco TruMac, LECO Corporation, St. Joseph, MI), NDF and ADF using an Ankom 200 Fiber Analyzer (Ankom Technology, Macedon, NY), and crude fat using an Ankom XT10 fat extractor (Ankom Technology, Macedon, NY). Feed ingredient compositions were used to construct overall diet composition.

**Statistical Analysis.**

The MIXED procedure (SAS Version 9.4, SAS Inst. Inc., Cary, NC) was utilized to analyze all variables excluding cow reproductive performance, calf morbidity, and calf mortality. Pen was used as the experimental unit. Fixed effects included treatment and cow age in the model statements for all variables for cows and calves, excluding calf morbidity and mortality. The AI sire was included as a fixed effect in the models for all variables pertaining to calf performance. Least square means function of SAS was used to separate treatment means. The GLIMMIX procedure (SAS Version 9.4, SAS Inst. Inc., Cary, NC) was utilized to analyze cow
reproductive performance (AI conception rate and overall pregnancy rate) and calf morbidity and mortality using binomial distributions. Significance was declared at P ≤ 0.05 and trends will be discussed at 0.05 < P ≤ 0.10. Synchronization treatment was included in the model, and was not significant.

RESULTS AND DISCUSSION

Cow Performance.

Cow BW and BCS data are reported in Table 2. There was a difference in cow BW at the initiation of the supplementation period (P = 0.05). Cows assigned to CSMAX treatment were lighter (675 kg) compared with CON supplemented cows (699 kg). The initial differences were a result of cows not being assigned by BW but rather by calving date. A single shrunk cow BW was recorded within 24 hours postpartum which allowed for variation, yet, initial BCS didn’t differ (P = 0.39). At the end of the treatment period, final BW did not differ (P = 0.30) nor did cow BCS (P = 0.34). However, there was a trend (P = 0.07) for cows on corn stalk maximizer supplemented diets to lose less BW from the beginning of the trial through the end of the treatment period. This difference did not reflect a change in cow BCS from initial to end of treatment (P = 0.82). At weaning there was no difference in cow BW (P = 0.32) or cow BCS (P = 0.44). This was not surprising as all cow calf pairs were commingled and managed as a single group. This translated to no differences in cow BW change from initiation of the treatment to weaning (P = 0.32) and cow BCS from the initiation of treatment to weaning (P = 0.84). Additionally, a significant improvement in diet digestibility (P < 0.01) for the CSMAX supplemented cows (70%) when compared to the CON (63%). This is supported by CSMAX cows losing less weight during the treatment period.
Similar impacts on BW change were observed by Linneen et al. (2014) when Bio-Mos® (Alltech, Inc.) was supplemented (10 g/d) in late gestation through 30d postpartum. Cows tended to lose less BW and BCS from parturition through the end of the feeding period. However, Franklin et al. (2005) failed to see a response in any cow variables when Bio-Mos® (Alltech, Inc.) was supplemented to dairy cows (10 g/d) in late gestation. Improvements to cow performance can also be attributed to the use of the exogenous enzyme Fibrozome (Alltech. Inc.). The addition of exogenous enzymes (0.52g/kg DM TMR) has been reported to improve DMI and increase ADG in growing steers fed high forage diets (Gómez-Vázquez et al., 2003; Vera et al., 2012). On the other hand, Eun et al. (2009) applied the same enzyme product to low forage feedlot steer diet at a rate 1 and 2 g/kg DM TMR and this resulted in no effect on growth performance, despite minor improvements in carcass characteristics. More research is needed to quantify the interaction between enzyme type and forage level. Diets with a greater inclusion of a poor quality forage may have a more potential for an improvement in cow performance.

Studies evaluating the impact of supplementing a chelated trace mineral compared to inorganic mineral to beef cows have not observed a change in cow BW, BCS, or digestibility (Swenson et al., 1998; Stanton et al., 2000; Ahola et al., 2004; Daugherty et al., 2002). Considering that most studies that have evaluated the impact of a mycotoxin binder have been performed on dairy cattle, performance variables like BW and BCS have not been recorded.

Milk Production, Reproductive Performance, and Incidence of Digital Dermatitis.

Cow milk production and reproductive performance and incidences of DD are shown in Table 3. Milk production did not differ ($P = 0.71$) between treatments. No differences ($P = 0.82$) in AI conception rate between CSMAX (68.1%) and CON (64.5%) supplemented cows were observed. Similarly, overall pregnancy rate did not differ ($P = 0.78$). Additionally, there were no
differences in the percentage of cows treated for DD ($P = 0.48$). No differences in cow milk production nor reproductive performance have been noted when evaluating the impact of Bio-Mos® (Alltech, Inc.) when supplemented to cows. Most studies evaluating the efficacy of exogenous enzymes in cattle have been performed on growing steers which provided little insight into the impact enzymes may have on milk production and reproductive performance.

Contrary to these results, studies that fed a supplemented chelate trace mineral and compared it to inorganic mineral forms have observed improvements in milk production in heifers (Swenson et al., 1998), yet, in similar studies on cows there were no differences in milk production (Swenson et al., 1998; Stanton et al., 2000; Ahola et al., 2004; Daugherty et al., 2002). While the addition of a mycotoxin binder reduced milk aflatoxin residues (Diaz et al., 2004), there were no changes in overall milk production and reproductive performance (Diaz et al., 2004; Stroud, 2006).

Supplementation of a chelated trace mineral and its effects on cow reproductive performance have varied greatly among different geographical locations and breed makeup of cow herd. Feeding a chelated trace mineral compared to an inorganic control has resulted in significant improvements in conception rates to AI (Swenson et al., 1998; Stanton et al., 2000; Ahola et al., 2004). However, studies by Vanegas et al. (2004) and Daugherty et al. (2002) noted no improvements in AI conception rate when comparing cows supplemented chelated trace minerals compared to cows supplemented an inorganic control. Yet, all of these studies failed to see an improvement in overall pregnancy rate. It is possible that the CON supplemented cow’s requirement for Cu, Zn, Mg, Co, and Se were being achieved through the supplementation of the inorganic mineral included in CON supplement.
Zinc plays an important role in maintaining the structural integrity of tissues, such as epithelial tissue (Larson, 2005). Chelated trace mineral supplementation aided in the control of DD and reduced the size of active lesions (Gomez et al., 2014). Furthermore, Kulow et al. (2017) evaluated the prevalence of Digital Dermatitis and the effects on performance in beef feedlot cattle supplemented with either a chelated trace mineral or a control inorganic supplement. Authors noted a significantly higher prevalence of Digital Dermatitis in the control cattle. Additionally, growth performance, final live weight, and hot carcass weight were affected when cattle were observed with a Digital Dermatitis lesion. Considering overall prevalence of DD, the experiment was underpowered to detect a change in DD lesions.

**Calf Performance and Health.**

Calf BW and health records are shown in Table 4. In spite of cow BW differing at the initiation of the trial, calf birth BW did not differ ($P = 0.14$). Additionally, there were no differences in calf BW at time of WSW ($P = 0.55$), or at weaning ($P = 0.19$). There were no differences in the percentage of calves treated for navel infections ($P = 0.47$), respiratory illness ($P = 0.30$), and incidences of scours ($P = 0.57$) between the treatment groups.

Calf health benefits have been observed in a study by Franklin et al. (2005) when Bio-Mos® (Alltech, Inc.) was fed to cows (10 g/d) in late gestation and there was a tendency for increases in serum protein concentration in calves from cows with Bio-Mos® (Alltech, Inc.) compared to cows fed control diet. The authors suggested that this increase in serum protein concentration was a result of increased transfer of passive immunity. Considering that serum protein concentration mirrors serum Ig concentrations, serum protein concentrations are of value in monitoring serum Ig concentrations in cows as well as calves. However, in this trial supplementation did not start until after parturition. Additionally, Heinrichs et al. (2003)
compared supplementing Bio-Mos® (Alltech, Inc.) in milk replacer at a rate of 4 g/d against a control milk replacer with no additives on Holstein calves. Authors noted a decrease in the event of calf scours which led to an increase in feed intake. However, Morrison et al. (2010) included Bio-Mos® (Alltech, Inc.) in milk replacer to Holstein calves at a higher rate of 10 g/d and compared it to control with no antibiotic. As hypothesized, feed intake was increased at four weeks of age, but, this did not translate into an increase in production measures such as live weight nor a decline in the number of scour episodes in the Bio-Mos® (Alltech, Inc.) treatments. Furthermore, Linneen et al. (2014) evaluated the efficacy of Bio-Mos® (Alltech, Inc.) on beef cow performance and calf immunity when supplemented (10 g/d) from late gestation through 30 d of lactation. They observed no differences in any calf immunity parameters measured. The addition of Fibrozyme® (Alltech, Inc.) to beef cows and its impact on cow or calf health has not been evaluated in any previous research.

With inconsistent results and minimal research on the impact of mycotoxin binders in limit fed beef cow diets provides little insight if a mycotoxin binder can affect cow or calf health.

**IMPLICATIONS**

Cows supplemented with an inorganic trace mineral supplement achieved an acceptable AI pregnancy rate, milk production, and minimal health issues. The addition of cornstalk calving maximizer TMR to cornstalk based TMR diet increased DM digestibility and cows tended to lose less BW during the treatment period. Yet, it did not improve overall BW change, BCS, AI conception, or health when supplemented from parturition to AI in a drylot system. Supplementation may need to start in late gestation or cows may need to be managed in a more challenged environment to observe a response to these technologies.
### Table 1. Ingredient composition of cow diets\(^1\) (% DM basis)

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>CSMAX(^2)</th>
<th>CON(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingredient, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn silage</td>
<td></td>
<td>45.6</td>
<td>45.6</td>
</tr>
<tr>
<td>Corn stalks</td>
<td></td>
<td>32.6</td>
<td>32.6</td>
</tr>
<tr>
<td>MDGS(^4)</td>
<td></td>
<td>19.6</td>
<td>19.6</td>
</tr>
<tr>
<td>CON supplement(^5)</td>
<td></td>
<td>-</td>
<td>2.2</td>
</tr>
<tr>
<td>CSMAX supplement(^6)</td>
<td></td>
<td>2.2</td>
<td>-</td>
</tr>
<tr>
<td>Analyzed nutrient content</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP, %</td>
<td></td>
<td>13.0</td>
<td>13.0</td>
</tr>
<tr>
<td>NDF, %</td>
<td></td>
<td>55.8</td>
<td>55.9</td>
</tr>
<tr>
<td>ADF, %</td>
<td></td>
<td>31.4</td>
<td>31.4</td>
</tr>
<tr>
<td>Crude fat, %</td>
<td></td>
<td>2.7</td>
<td>2.7</td>
</tr>
</tbody>
</table>

\(^1\) All were limit fed 12.7 kg·cow\(^{-1}·d\(^{-1}\) on a DM basis.

\(^2\) Cows were supplemented with 0.30 kg of DM Cornstalk Calving Maximizer TMR\(^®\) (US Feeds; Eldora, IA).

\(^3\) Cows were supplemented with 0.30 kg of DM Control (US Feeds; Eldora, IA).

\(^4\) Modified distillers grains with solubles.

\(^5\) Control supplement (US Feeds; Eldora, IA). Wheat midds based supplement contained: 10.6% Ca, 2.8% P, 1.1% Mg, 1.11% K, 0.38% S, 1,176.80 mg/kg of Mn as MnO\(_2\), 412.86 mg/kg of Cu as CuSO\(_4\), 1,467.27 mg/kg of Zn as ZnSO\(_4\), 1,235.08 mg/kg of Fe, 8.75 mg/kg of Se as Na\(_2\)SeO\(_3\), 32.87 mg/kg of Co as CoCO\(_3\), 70.91 mg/kg of I, 324.33 KIU/kg vitamin A, 32.61 KIU/kg vitamin D, and 1617.56 IU/kg of vitamin E.

\(^6\) Cornstalk Calving Maximizer TMR\(^®\) (US Feeds; Eldora, IA). Same as control except; 9.6% Ca, 2.5% P, 1.00% Mg, 1.00% K, 0.31% S, trace minerals were combination of inorganics (same source as control) and chelates; 1,075.00 mg/kg of Mn (280.00 mg/kg as Bioplex\(^®\)), 376.80 mg/kg of Cu (140.00 mg/kg as Bioplex\(^®\)), 1340.00 mg/kg of Zn (560.00 mg/kg as Bioplex\(^®\)), 1,249.95 mg/kg of Fe, 8.00 mg/kg of Se (Selplex 2000\(^®\)), 30.00 mg/kg of Co (3.50 mg/kg as Bioplex\(^®\)), 65.00 mg/kg I, 297.62 KIU/kg vitamin A, 29.76 KIU/kg vitamin D, and 1477.095 IU/kg of vitamin E, 3% Integral A+\(^®\) (provides 10 g·cow\(^{-1}·d\(^{-1}\)), 3% Bio-Mos\(^®\) (provides 10 g·cow\(^{-1}·d\(^{-1}\)), 2.35% Fibrozyme\(^®\) (provides 8 g·cow\(^{-1}·d\(^{-1}\)). All technologies from Alltech, Nicholasville, KY.
Table 2. Influence of supplementation type on cow BW, BCS, and digestibility

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>CSMAX¹</th>
<th>CON²</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td></td>
<td>675</td>
<td>699</td>
<td>7.7</td>
<td>0.05</td>
</tr>
<tr>
<td>Breeding</td>
<td></td>
<td>657</td>
<td>657</td>
<td>7.7</td>
<td>0.30</td>
</tr>
<tr>
<td>Weaning</td>
<td></td>
<td>606</td>
<td>606</td>
<td>14.0</td>
<td>0.32</td>
</tr>
<tr>
<td>BW change, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial to Breeding</td>
<td></td>
<td>-27</td>
<td>-46</td>
<td>15</td>
<td>0.07</td>
</tr>
<tr>
<td>Initial to Weaning</td>
<td></td>
<td>-82</td>
<td>-72</td>
<td>14</td>
<td>0.32</td>
</tr>
<tr>
<td>BCS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td></td>
<td>6.3</td>
<td>6.4</td>
<td>0.1</td>
<td>0.39</td>
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<tr>
<td>Breeding</td>
<td></td>
<td>5.8</td>
<td>5.9</td>
<td>0.1</td>
<td>0.34</td>
</tr>
<tr>
<td>Weaning</td>
<td></td>
<td>5.7</td>
<td>5.9</td>
<td>0.1</td>
<td>0.44</td>
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<tr>
<td>BCS change</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Initial to Breeding</td>
<td></td>
<td>-0.5</td>
<td>-0.5</td>
<td>0.1</td>
<td>0.82</td>
</tr>
<tr>
<td>Initial to Weaning</td>
<td></td>
<td>-0.6</td>
<td>-0.6</td>
<td>0.1</td>
<td>0.84</td>
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<tr>
<td>Digestibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM Digestibility, %</td>
<td></td>
<td>70.0</td>
<td>63.0</td>
<td>0.8</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

¹CSMAX ration: 4.3 kg of corn silage, 5.2 kg corn stalks, 2.9 kg DDGS, and 0.30 kg of Cornstalk Calving Maximizer TMR® [US Feeds; Eldora, IA; wheat midds based supplement including; chelated trace minerals (Cu, Zn, Mn, and Co as Bioplex® and Se as Selplex 2000®), 3% Intergral A+® (provides 10 g·cow⁻¹·d⁻¹), 3% Bio-Mos® (provides 10 g·cow⁻¹·d⁻¹), and 2.35% Fibrozyme® (provides 8 g·cow⁻¹·d⁻¹)] on a DM basis. All technologies from Alltech, Nicholasville, KY.

²CON ration: 4.3 kg of corn silage, 5.2 kg corn stalks, 2.9 kg DDGS, and 0.30 kg of Control supplement (US Feeds; Eldora, IA; wheat midds based supplement including inorganic trace minerals) on a DM basis.
Table 3. Influence of supplementation type on cow milk production and reproduction

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>CSMAX¹</th>
<th>CON²</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk production, kg/d</td>
<td></td>
<td>9.1</td>
<td>9.5</td>
<td>0.5</td>
<td>0.71</td>
</tr>
<tr>
<td>Reproduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AI conception, %</td>
<td></td>
<td>68.1</td>
<td>64.5</td>
<td>-</td>
<td>0.71</td>
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<tr>
<td>Overall pregnancy, %</td>
<td></td>
<td>91.7</td>
<td>89.6</td>
<td>-</td>
<td>0.78</td>
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<tr>
<td>Cow health</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Dermatitis, %</td>
<td></td>
<td>21</td>
<td>27</td>
<td>-</td>
<td>0.48</td>
</tr>
</tbody>
</table>

¹CSMAX ration; 4.3 kg of corn silage, 5.2 kg corn stalks, 2.9 kg DDGS, and 0.30 kg of Cornstalk Calving Maximizer TMR® [US Feeds; Eldora, IA; wheat midds based supplement including; chelated trace minerals (Cu, Zn, Mn, and Co as Bioplex® and Se as Selplex 2000®), 3% Intergral A+® (provides 10 g·cow⁻¹·d⁻¹), 3% Bio-Mos® (provides 10 g·cow⁻¹·d⁻¹), and 2.35% Fibrozyme® (provides 8 g·cow⁻¹·d⁻¹)] on a DM basis. All technologies from Alltech, Nicholasville, KY.

²CON ration; 4.3 kg of corn silage, 5.2 kg corn stalks, 2.9 kg DDGS, and 0.30 kg of Control supplement (US Feeds; Eldora, IA; wheat midds based supplement including inorganic trace minerals) on a DM basis.
Table 4. Influence of supplementation type on calf performance and health.

<table>
<thead>
<tr>
<th>Item</th>
<th>CSMAX(^1)</th>
<th>CON(^2)</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>37</td>
<td>39</td>
<td>1</td>
<td>0.14</td>
</tr>
<tr>
<td>WSW</td>
<td>107</td>
<td>113</td>
<td>7</td>
<td>0.55</td>
</tr>
<tr>
<td>Weaning</td>
<td>186</td>
<td>200</td>
<td>7</td>
<td>0.19</td>
</tr>
<tr>
<td>Calf health</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Navel infections, %</td>
<td>13</td>
<td>23</td>
<td>-</td>
<td>0.47</td>
</tr>
<tr>
<td>Respiratory, %</td>
<td>6</td>
<td>13</td>
<td>-</td>
<td>0.30</td>
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<tr>
<td>Scours, %</td>
<td>15</td>
<td>10</td>
<td>-</td>
<td>0.57</td>
</tr>
</tbody>
</table>

\(^1\)CSMAX ration; 4.3 kg of corn silage, 5.2 kg corn stalks, 2.9 kg DDGS, and 0.30 kg of Cornstalk Calving Maximizer TMR\(\textregistered\) [US Feeds; Eldora, IA; wheat midds based supplement including; chelated trace minerals (Cu, Zn, Mn, and Co as Bioplex\(\textregistered\) and Se as Selplex 2000\(\textregistered\)), 3% Intergral A+\(\textregistered\) (provides 10 g·cow\(^{-1}\)·d\(^{-1}\)), 3% Bio-Mos\(\textregistered\) (provides 10 g·cow\(^{-1}\)·d\(^{-1}\)), and 2.35% Fibrozyme\(\textregistered\) (provides 8 g·cow\(^{-1}\)·d\(^{-1}\))] on a DM basis. All technologies from Alltech, Nicholasville, KY.

\(^2\)CON ration; 4.3 kg of corn silage, 5.2 kg corn stalks, 2.9 kg DDGS, and 0.30 kg of Control supplement (US Feeds; Eldora, IA; wheat midds based supplement including inorganic trace minerals) on a DM basis.

Anderson, V. L., and S. L Boyles. 2007. Dry lot beef cow/calf production. Fact sheet #AS -974 (revised) North Dakota State University Experimental Station and Ohio State University, USA.


