12-2012

EVALUATION OF SOYBEAN HULLS AND FEED ADDITIVES IN FINISHING BEEF DIETS

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by

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A THESIS

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Science

Major: Animal Science

Under the Supervision of Professors

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Lincoln, Nebraska

December, 2012

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University of Nebraska, 2012

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Replacing the amount of corn in finishing diets with ethanol byproducts, such as distillers grains, has been well researched and improves performance. However, research when including soybean hulls (SBH) in feedlot finishing diets with distillers grains is limited. Two feedlot experiments were conducted to evaluate the effects of SBH on animal performance and carcass characteristics in finishing diets. Dietary concentrations of SBH used were 0, 12.5, 25, and 37.5% of diet DM, in both experiments. Modified distillers grains plus solubles was included in the diet at 25% for Exp.1 while Exp. 2 contained an inclusion level of 40% wet distillers grains plus solubles (DM basis). In Exp. 1, as SBH concentrations increased, DMI decreased linearly when fed to yearling steers. Response to increasing concentrations of SBH, resulted in ADG and G:F decreasing linearly when utilizing yearlings. Utilizing calf-feds in Exp. 2, there was a tendency for a linear increase in ADG; gain was greatest with the inclusion of 12.5% SBH. Gain to feed tended to respond quadratically, with optimum inclusion of SBH being 12.5%. The feeding value of SBH at concentrations of 12.5 and 25% were greater than that of corn when wet distillers grains plus solubles (WDGS) was included in the diet. In an effort to optimize feed utilization and animal performance, a cattle finishing experiment was conducted evaluating the effects of NEXT ENHANCE (NEX) and monensin/tylosin (MT) on feedlot performance, carcass characteristics, and liver abscesses in finishing diets. There was no significant MT x NEX interaction, therefore main effects are presented. In diets containing MT, a 3.9% improvement in G:F was observed but when feeding NEX, G:F was not affected. Incidence of liver abscesses decreased 45.7% when MT was fed compared to diets without MT. Feeding soybean hulls at 12.5% can replace a portion of corn in finishing diets with WDGS and with the use of monensin plus tylosin an improvement in G:F can be expected.

Key Words: essential oils, finishing cattle, monensin, soybean hulls, tylosin

Acknowledgements

I want to thank Drs. Terry Klopfenstein and Galen Erickson for giving me the opportunity to come to graduate school at UNL, advising me when in times of need, and pushing me to exceed. Also, thank you Drs. Paul Kononoff and Matt Luebbe for serving on my examining committee. Your guidance and knowledge was very helpful. Thank you to the technicians and my fellow graduate students for all your help along the way. Thank you to my family and friends that have encouraged me to get to where I am today. Thank you to Kayla for listening, helping, and encouraging me during stressful times throughout my master program. Lastly, if it wasn't for the UNL Feedlot Management Internship Program, I would have never met a good friend, Alex Titlow, thanks.

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REVIEW OF LITERATURE

Characterizing Soyhulls

Production of Soybeans. Of the major crops produced in the United States today, soybean production ranks 2^{nd}. Reports from the USDA in 2011(NASS, 2012), indicate that 74.9 million acres were planted, producing over 3.0 billion bushels of soybeans; and of that, Nebraska alone produced 258 million bushels, the third largest production on record for Nebraska. Soybeans are crushed domestically to produce their primary product, soybean oil, and a major co-product, soybean meal. Another co-product of soybean crushing, soybean hulls (SBH), is the seed coat of the soybean that is removed during the grinding process. Sessa and Wolf (2001) reported that soybean coats, or SBH, represent eight percent of the weight of the soybean. Using an estimate of eight percent, Nebraska produced roughly 620,000 tons of SBH. Given the abundant availability of SBH, this may allow Nebraska beef producers the opportunity to reduce feed costs if the price of SBH relative to corn is competitive.

Soybean Processing. Currently, there are 57 soybean processing facilities in the United States, two being located in Nebraska (Soybean Info Center, 2012). Today, nearly 99% of U.S. processing facilities use a method involving the use of solvent extraction. The process involves three steps: (1) soybean preparation, (2) oil extraction, and (3) soybean meal formulation (United Soybean Board, 2012). Initially, all soybeans are graded and cleaned of any foreign material before processing. During the preparation stage, the soybean is cracked with a roller to reduce size and ease the removal of the hull from the meat of the seed. Once the bean has been cracked, hulls are removed via aspiration leaving two parts, SBH and meats. The meats are then heated and undergo a flaking process, then extracted with hexane. These steps allow for the removal of oil from the soybean flake. Once the oil is removed, the soybean flakes, which are called "spent flakes," are then toasted to remove any residual hexane and also to inactivate enzymes that may reduce the digestibility or nutritional value of the meal. Once the flakes have been screened and ground with a hammer mill, a high protein co-product is formed called soybean meal (48% CP). The SBH is ground and toasted, then can either be blended back with the meal to produce 44% CP soybean meal or sold as SBH. Traditionally, the hulls were blended with soybean meal to produce 44% CP soybean meal, but most meal currently produced is 48% CP.

Today, with swine and poultry industries combining to utilize 70 to 75% of soybean meal (American Soybean Association, 2011) and their limited ability to digest fiber (Kohlmeier, 1996), smaller quantities of SBH are blended into soybean meal allowing for an increase in availability of SBH to be of large amounts for cattle feeding.

Nutrient Composition. Soybean hulls consist mostly of fiber and comparable amounts of crude protein as to that of corn grain. However, the fiber component is low in lignin, making it highly digestible. The NRC (1996) reports the composition of SBH to be 66.3% ± 2.03 (n=6) NDF, 12.2% ± 2.51 (n=27) CP, and 2.1% ± 0.56 (n=17) fat, respectively. Belyean et al. (1989) evaluated the variation in co-products over a 10-d processing period with samples taken every one to two hours and reported the composition of soyhulls to be 72.5% NDF, 11.8% protein, 4.3% lignin, and 0.8% fat. Hsu et al. (1987) reported similar values to this; however, they reported the fat content of soyhulls to be 4.3%, which is greater than that of the NRC (1996). Anderson et al. (1988b) reported that cleaned soybean hulls contain 73.7% NDF and 9.4% crude protein.

However, Batajoo and Shaver (1998) analyzed six samples of SBH and reported the CP content to be 19.2% ± 0.3 and to contain 53.4% ± 0.2 NDF. The energy content of SBH is estimated as 80% TDN, 1.94 Mcal/kg of NE_m, and 1.30 Mcal/kg of NE_g (NRC, 1996). Furthermore, the energy content of SBH has been evaluated to be comparable to corn (Anderson et al., 1988a; Galloway et al., 1993) when supplemented with low-to-moderate quality forages and to have a feeding value of 74-80% of corn when used in finishing diets (Ludden et al., 1995). These results demonstrate that the nutrient composition can vary widely between processors and should be taken into consideration when feeding to livestock.

The cost to transport SBH from processing facilities often limits their use due to the low bulk density. During processing, soyhulls are finely ground to increase their density for transportation and to be blended back with soybean meal more easily. Letsche et al. (2009) reported that the bulk density of soyhulls is 0.37 g/cm^3 compared to 0.59 to 0.72 g/cm^3 of that of corn. After processing, finely ground soyhulls present a challenge when it comes to the amount of soyhulls that are lost due to shrink. Feed shrink, is defined by Barmore (2012) to be the amount of feed lost from the point of purchase to when the animal actually consumes the product. This amount would include transporting, storing, handling, discharging, and mixing the feed along with other activities that increase loss. An alternative to prevent the amount of product lost and increase bulk density is to pellet the SBH. Pelleting of SBH has been shown to increase bulk density up to 3.7 times (Merrill, 1984) therefore making transportation more economical. However, Anderson et al. (1988b) observed ground SBH to have a lower energy value than whole SBH, likely due to rapid passage from the rumen.

Effects on Animal Performance

Forage supplementation. The use of SBH as an alternative energy source to cereal grains has been evaluated when fed to growing cattle (McDonnell et al., 1983; Hibberd et al., 1987; Anderson et al., 1998a). When feeding high amounts of low fiber, high starch diets to cattle grazing forages, negative impacts on forage intake and digestion may occur (Chase and Hibberd, 1987; Galloway et al., 1993). However, with supplementation of a high-fiber energy source such as SBH, Grigsby et al. (1992) reported that the negative effects on fiber digestion were not present compared to that of cereal grain supplementation.

Anderson et al. (1988a) conducted five grazing studies to evaluate SBH as an energy supplement. The first trial utilized regrowth of smooth brome grass pastures with 48 steers being assigned to one of three treatments. Treatments were 1) no supplement, 2) rolled corn or 3) whole untoasted SBH. Treatments were supplemented at a rate of 1.36 kg DM/hd/d. Results displayed a numeric tendency for increased daily gain based on energy supplementation, although not significant. The authors suggest that due to the regrowth being lush, green and of high quality, the steers were not energy deficient therefore response due to energy supplementation would be minimal. The second study Anderson et al. (1988a) evaluated energy supplements (no supplement, rolled corn, ground SBH, or whole SBH) at 1.36 kg/ DM/hd/d with cattle grazing smooth brome grass for 138 d during the summer period. Both SBH supplements were pelleted and results indicated no significant differences in daily gain for cattle fed corn, ground SBH, or whole SBH, but supplemented cattle gained more rapidly than non-supplemented cattle. In this series of experiments trials three and four were pooled together over two years; heifers supplemented with 1.36 kg DM/hd/d of corn or whole SBH increased ADG compared to that of non-supplemented heifers, while heifers fed SBH tended to support higher gains than that of corn-fed heifers while grazing cornstalks. In the final study, steers grazing smooth brome pastures from approximately mid-May to mid-September that were supplemented with SBH the entire grazing season, last half of the grazing season, or gradually increasing the amount of SBH weekly. Supplementing SBH the last half of the grazing season or gradually increasing supplement improved ADG compared to cattle that were supplemented SBH the entire grazing season. This is attributed to smooth brome grass being at lowest quality and quantity levels (Waller et al., 1986) from July until the end of trial; therefore these two supplementation regimens were advantageous to the production of smooth brome grass during this time.

In agreement with Anderson et al. (1988a), a study conducted by Garcés-Yépez et al. (1997) observed that when supplementing corn-soybean meal (CSBM) or SBH at less than 0.5% BW, no difference in ADG was observed; however, when supplementing at levels between 0.8% - 1.0% BW, ADG was increased for SBH supplemented cattle. Similarily, Heird et al. (1994) performed a trial in which steers consuming Bermuda grass hay were offered no energy supplement (control), ground corn (0.75% BW) plus monensin, or SBH (1.05% BW) over an 84-d period. Supplementing cattle with SBH resulted in increased ADG compared to corn supplementation (1.20, 1.09, and 0.56 kg/d for SBH, corn, and control, respectively). From these results we can conclude that the energy value of SBH is at least equal to or even greater than that of corn depending on level of supplementation to grazing cattle. When cattle are supplemented on forages with cereal grains that are high in starch, a negative associative effect on intake and fiber digestion (Chase and Hibberd, 1987; Galloway et al., 1993) is observed due to the starch being rapidly fermented in the rumen causing acidic conditions. However, supplementing forage diets with SBH, generally results in a positive associative effect (Anderson et al., 1988a; Anderson et al., 1988b; Grigsby et al., 1992) because SBH are a highly digestible source of fiber that minimally alters ruminal fermentation.

Receiving diets. Of the reviewed literature, few studies have evaluated incorporating SBH in receiving diets for cattle, but findings display fairly consistent results. A trial conducted by Wahrmund et al. (2011) evaluated the use of individually supplementing dried distillers grains (DDG), SBH, or a combination of both energy supplements daily along with ad libitum access to bahiagrass hay to steers (n=56; BW = 274 ± 26 kg) for 42-d. Treatments were formulated to provide adequate energy in order to achieve 0.91 kg/d of ADG; however, subsequent analysis showed that total digestible nutrients (TDN) of SBH were 23% lower than anticipated. Supplement treatment had no effect on BW gain over the 42-d receiving period. From d 0 – 42, ADG was not different between DDG and SBH; however, cattle fed a combination of DDG and SBH resulted in greater daily gains compared to SBH supplemented cattle. Another study evaluating the replacement of dry rolled corn (DRC) with SBH in beef cattle receiving diets was conducted by Mueller et al. (2011) over two years. Two-hundred seventy-one calves were received on an oat silage-based diet consisting of starch (HS) from DRC or digestible fiber (HF) from SBH and fed for either 74-d in year 1 or 70-d in year 2. Dry matter intake was greater for steers fed HF in year 1 compared with steers fed HS, but was not different in year 2. Across years, ADG and G:F were similar between treatments over the entire receiving period. Similarly, a study conducted by Anderson and Schoonmaker (2005) evaluated the replacement of corn with SBH (0, 15, 30, or 45% DM basis) in a 42-d receiving study. There were no significant differences in G:F or DMI between treatments. Average daily gains were 1.87, 1.96, 1.80, and 1.71 kg/d for dietary treatments 0, 15, 30, and 45% SBH diet, respectively. Gains were similar at the 0% and 15% inclusion level of SBH, but the 30% diet was not significantly different from 0%, suggesting that the replacement of corn up to 30% SBH is favorable for ADG. A study conducted by Bunyecha (2005) received 36 steers on four treatments that contained SBH (0, 25, 50, and 75% DM basis) replacing corn and evaluated the effects on animal performance over a 63-d period. The remainder of the diet consisted of approximately 15% DM cottonseed hulls and supplement. For steers fed 0 and 25% SBH, ADG was greatest over the 63-d period with responses at 50 and 75% SBH being similar. Feed efficiency (G:F) were numerically greatest for steers fed 0% SBH; however, inclusion of 25 or 75% SBH were not statistically different from cattle fed 0% SBH. Poorest feed conversions were observed when cattle were fed 50% SBH, but were statistically similar to inclusion of 25 or 75% SBH. The author concluded that including 25% SBH in receiving rations for beef cattle is an alternative choice to replace corn. Results from these studies demonstrate that the use of SBH is suitable for stimulating appetite in newly received beef calves while achieving adequate performance.

Backgrounding diets. Generally, calves are first introduced to dry feed during the backgrounding phase of production where the diet consists mostly of forages. A trial conducted by Swanson et al. (2007) studied the effects of including 20% (DM basis) of either cracked corn or pelleted SBH with haylage diets on backgounding calves (n=48) for 112 d. Results indicated that DMI, ADG, and G:F were greater for steers fed cracked corn and SBH compared to the haylage control, but no differences were observed between steers fed corn and SBH. With a basal ration of 1:1:1 mixture of NH_3-treated oat straw, indian grass hay, and brome-alfalfa hay, McDonnell et al. (1983) determined the effects of adding energy at 15 and 30% of the ration with three different energy sources (cracked corn, ground SBH, or whole SBH) over a 112 d growing period. Greatest ADG (0.83 kg/d) and most desirable G:F were observed when using corn as an energy source. Feeding cattle ground SBH resulted in greater DMI and poorer feed efficiencies; however, with the use of whole SBH, response in G:F was similar to corn but ADG was lower. These results agree with Hsu et al. (1987) where they fed steers a basal diet of fescue silage along with energy supplements of corn, corn fiber, or SBH and noted less desirable feed conversions (6.00 vs 5.56 kg/d), but observed similar gains (1.11 vs 1.15 kg/d) with steers fed SBH versus that of corn. Hsu et al. (1987) conducted another trial evaluating the same energy supplements as previously described but with the inclusion of corn silage as the basal feed ingredient in a 101 d growing study. Again, steers fed SBH had similar weight gains, but greater intakes resulting in poorer feed conversions compared to steers fed corn.

A study conducted by McDonnell et al. (1982) evaluated increasing levels of ground SBH and corn (0, 12.5, 25, or 50% of diet) being fed with a 1:1:1 mixture of corn stalklage, ground corn cobs, and brome hay over a 120 d period. Results within an energy level showed that DMI, ADG and F:G were not different when comparing corn and SBH. However, cattle fed SBH tended to have greater intakes as energy levels increased with poorer feed efficiencies when compared to corn. The authors explained that the lower feed efficiencies is due in part to SBH *in vitro* dry matter disappearance being 78% compared to corn of 94% (McDonnell et al., 1982). Likewise, Allison et al.

(1995) supplemented 0, 1.13, 2.27, or 3.40 kg/d of SBH to growing steers fed ground hay. As SBH supplementation increased, hay intake decreased; however hay consumption was not different for steers supplemented 2.27 and 3.40 kg/d of SBH, respectively. Daily gains increased linearly with increasing levels of SBH resulting in favorable feed conversions with increasing levels of supplementation.

Garrigus et al. (1967) evaluated the effects of pelleting SBH on animal performance over a 168-d period. Soybean hulls were provided *ad libitum* in either ground or pelleted forms along with free access to bonemeal, salt, and water. Steers fed pelleted SBH gained more than ground SBH fed steers (0.68 vs 0.51 kg/d); daily intakes were similar, but feed per unit of gain was less for pelleted fed steers. Similarly, Drouillard and Klopfenstein (1988) compared the performance of steers fed pellets made from whole or ground SBH with *ad libitum* access to brome and alfalfa hay and they concluded that type of SBH pellet fed had no influence on ADG and G:F. Supplementing with a co-product, such as SBH, that is highly palatable and low in starch can be effectively used in backgrounding diets.

Finishing diets. Of the reviewed literature, experiments evaluating the inclusion of SBH in finishing diets are limited. In a study by Ludden et al. (1995), 120 steers were utilized over an 84-d feeding period to determine the feeding value of SBH while replacing corn in concentrate diets. Concentrations of SBH were 0, 20, 40, or 60% of diet DM. The trial ended on day 84 due to poor performance of steers at the 60% SBH inclusion level. As concentration of SBH increased, ADG decreased linearly (1.40 vs 1.19 kg/d) and, DMI increased linearly, resulting in poorer feed efficiencies. The feeding value of SH was calculated to be 74 to 80% relative to corn based upon observed animal performance observed. In a feedlot study with lambs, Ferreira et al. (2011) fed increasing concentrations of SBH (0, 10.5, 21, or 31.4% diet DM) while replacing corn. They reported that as SBH increased, DMI increased linearly, but ADG was not different among concentrations of SBH; however, feed efficiency decreased linearly with increasing levels of SBH.

Homm et al. (2008) evaluated feeding a combination of 40% dried distillers grains with solubles (DDGS) along with 35% SBH (DM basis) over a 196 d period. Treatments consisted of feeding the diet for 56, 84, 112, 140, and 196 days before changing to a corn based finishing diet. Final BW, ADG, DMI, and HCW increased linearly as days on the DDGS-SBH diet increased. With increasing days on the DDGS-SBH diet, feed efficiency decreased linearly. This is further supported by Trejo et al. (2009), where they grouped data from three experiments over three years utilizing 525 steers fed four diets. Dietary treatments were: 1) 75% DRC, 15% corn silage (CS); 2) 50% DRC, 25% dry distillers grains (DDG), 15% CS; 3) 40% DDG, 35% SBH, 15% CS; 4) 40% fresh modified wet distillers grains, 35% SBH, 15% CS. Steers fed treatment 3 had heaviest adjusted final weights while treatments 2 and 4 were not different from one another. Greatest DMI and ADG was observed with cattle being fed treatment 3 and intake for treatment 1 was lowest, but feed efficiency was similar across all four treatments. These data suggest that cattle can be finished on a combination of distiller's grains and SBH, and can attain performance equal to or greater than that you would typically see when using a traditional corn-based finishing diets.

Classification of bloat

Bloat is an excessive accumulation of gas in the rumen in which the animal's ability to expel the gas is inhibited (Clarke and Reid, 1974). Cattle can experience two types of bloat: frothy bloat and free-gas bloat. An obstruction in the esophagus which inhibits eructation is called free-gas bloat. Of the two, frothy bloat is most commonly observed in feedlot cattle. This is due to either feeding grains of small particle size that causes an entrapment of gases during fermentation or by the production of an insoluble slime that is formed by rumen bacteria when cattle are fed high concentrate diets causing a stable froth or foam to form.

Of the reviewed literature, minimal research exists when evaluating the relationship between SBH diets and the occurrence of bloat. Shriver et al., (2000) provided *ad libitum* access of SBH, SBH plus a 32% protein supplement, or protein supplement plus 0.68 kg/hd/d of long stem prairie hay to 78 steers. Of the steers fed the SBH treatment, 18.5% established symptoms of bloat while the addition of protein supplement and prairie hay to the diet significantly decreased the occurrence of bloat. They noted that nearly 10% of steers fed hay bloated one or more times during the study. A similar study conducted by Steele et al. (2001) allowed heifers free-choice access to SBH pellets and prairie hay. Heifers were fed either free-choice salt or a commercial monensin-containing mineral. The commercial mineral supplement contained 1,620 g/ton monensin. Average monensin consumption was 142 mg/hd/d. They reported that 6% of the heifers fed the monensin-containing mineral experienced bloat compared to 19% of the salt-fed heifers. These studies show that when feeding SBH at *ad libitum* intake, there is a chance of bloat occurring; however this can be minimized with the use of an effective fiber source and/or monensin. Furthermore, incidence of bloat was minimized when the inclusion of roughage source in diet was of long stem hay compared to that of chopped forages when feeding SBH (Berger, L.L. Univ. Neb., Lincoln, NE. Personal communication).

Essential Oils

General Information on Essential Oils and Different Types. The use of feed additives, such as antibiotic ionophores, are common in ruminant diets to improve the efficiency of energy and protein utilization in the rumen (Van Nevel and Demeyer, 1988). However, the public perception of using antibiotics in livestock production has changed, possibly due to the appearance of antibiotic resistant bacteria that may pose a risk to human health (Benchaar et al., 2008). Alternative methods to modulate ruminal fermentation to enhance animal productivity and improve feed efficiency have been explored.

Certain plants produce secondary metabolites (Greathead, 2003) which are used as a natural protection against microbial and insect attack (Wallace, 2004). Secondary metabolites are classified into 3 groups: saponins, tannins, and essential oils (EO). For the purpose of this literature review, EO will be the main area of focus. Essential oils are secondary plant metabolites that are obtained from the plant volatile fraction by steam distillation or with the use of organic-solvents (Wallace, 2004; Calsamiglia et al., 2007). Various parts of the plants can be utilized to obtain EO such as the leaves, flowers, roots, stems, bark, and seeds (Chaves et al., 2008a). However, Dorman and Deans (2000) described that different parts of the same plant can vary in composition of EO that is extracted. According to Calsamiglia et al. (2007) the term “essential” derives from “essence,” which means smell or taste and relates to the properties of these substances in providing specific flavors and odors to many plants. Most EO occur in two chemical groups: terpenoids and phenylpropanoids. Terpenoids are the most abundant and diversified plant secondary metabolites; they are derived from a five-carbon unit (C_5H_8), sometimes called an isoprene unit, and are classified depending on the number of five-carbon units in their structure (Gershenzon and Croteau, 1991). Common classification of terpenoids include hemiterpenoids, monoterpenoids, sesquiterpenoids, diterpenoids, triterpenoids, and tetraterpenoids (C_5, C_{10}, C_{15}, C_{20}, C_{30}, and C_{40}, respectively), with the most important components of EO belonging to the monoterpenoid and sesquiterpenoid families (Gershenzon and Croteau, 1991). Examples of terpenoids would include carvacrol and thymol, which are both found in oregano and thyme (Calsamiglia et al., 2007). Phenylpropanoids are the second chemical group of which EO occur and they are described as an aromatic ring of six carbons that has a side chain of three carbons attached to it (Calsamiglia et al., 2007). Common phenylpropanoids include cinnamadehyde (cinnamon), eugenol (clove bud and cinnamon), and anethol (anise; Calsamiglia et al., 2007).

Rumen Fermentation. Secondary plant metabolites have been shown to have antimicrobial activity (Cowan, 1999) against gram-positive and gram-negative bacteria. Most research on plant extracts and their effects on ruminal microbial fermentation have been conducted on high-forage diets with a pH > 6.0. Busquet et al. (2005) studied the effects of cinnamaldehyde (CIN; a natural chemical originating from bark of cinnamon trees) and garlic oil (GAR) on ruminal fermentation using continuous culture fermenters. The fermenters were inoculated with ruminal fluid from a fistulated steer fed 50:50 alfalfa hay:concentrate diet. Fermenters fed CIN (31.2 mg/L) decreased the proportion of acetate and increased the proportion of propionate. Similarly, feeding CIN at 312 mg/L resulted in decreasing the proportion of acetate, propionate being unchanged, but increasing the proportion of butyrate. The GAR at higher levels (312 mg/L) increased the proportion of propionate and butyrate and decreased the proportion of acetate. Conversely, Cardozo et al. (2004) studied the effects of including GAR at a lower level (0.22 mg/L) and found no effect on total VFA concentrations. Conclusions from these studies showed no effect on DM, OM, NDF, and ADF digestibilities or total VFA concentrations but the ratio of VFA's produced were favorably altered with the use CIN and GAR. In another trial, Busquet et al. (2006) studied the effects of various plant extracts on rumen fermentation in *in vitro* bath culture and CIN and GAR were included. Treatments were supplied at 3, 30, 300, and 3000 mg/L of culture fluid. Cinnamaldehyde had no effect on the proportions of acetate and butyrate but propionate increased. Proportion of acetate decreased with GAR (at 300 and 3000 mg/L) while propionate increased at 30 and 300 mg/L. Proportion of butyrate in GAR was increased at 3,000 mg/L. At high levels (3000 mg/L) of CIN and GAR, pH increased and total concentration of VFA decreased. A reduction in total VFA may result from the inhibition of microbial fermentation which would be unfavorable to the animal.

Evaluating the effects of plant extracts on *in vitro* microbial fermentation using a high-concentrate diet (pH of 5.5) was conducted by Cardozo et al. (2005). Plant extracts, GAR and CIN, at levels 0, 0.3, 3, 30, and 300 mg/L were evaluated. Supplementation of CIN (0.3, 3, and 30 mg/L) and GAR (3 and 30 mg/L) increased total VFA concentrations; however, high dosage levels (300 mg/L) of CIN and GAR resulted in suppressing total VFA concentration. With supplementation of CIN (3 and 30 mg/L) and GAR (30 mg/L), the acetate proportion decreased and propionate increased. These data support the use of CIN and GAR in high-concentrate diets due to the increase in total VFA concentration and favorable shift in acetate:propionate. Further evaluation of CIN (0, 400, 800, and 1600 mg/d) *in vivo* was conducted by Yang et al. (2010a). The authors reported no difference in total VFA concentrations, molar proportions of acetate, propionate, or butyrate, and acetate:propionate ratio. This work is supported by Cardozo et al. (2006) where they observed no difference in total VFA concentrations, molar proportions of individual VFA, or a change in acetate:propionate ratio when supplementing a mixture of CIN and eugenol. The lack of difference observed in total VFA concentrations and proportions could be partially attributed to rumen pH. Cardozo et al. (2005) illustrated a favorable difference in the VFA profile at a lower pH (5.5). However, rumen pH was generally higher than this (pH >5.82 and 5.91) for trials of both Yang et al. (2010a) and Cardozo et al. (2006), respectively.

Effects on Animal Performance and Carcass Characteristics. Few studies have investigated the effects of EO on intake, ADG, G:F, and carcass characteristics when fed to beef cattle. Yang et al. (2010b) supplemented CIN at increasing dosage amounts (0, 400, 800, or 1600 mg/steer daily) to steers fed a high-concentrate diet of 86% dry-rolled barley grain, 9% barley silage, and 5% supplement (DM basis). Dry matter intake tended (P = 0.09) to respond quadratically to the level of CIN supplementation, with steers being fed 1600 mg/d having numerically lower DMI (7.69 kg/d) while greatest intakes (8.42 kg/d) were observed at 400 mg/d CIN. Final BW, ADG, feed efficiency (G:F), and carcass characteristics were not affected by CIN supplementation. In another study, Meyer et al. (2009) conducted an experiment evaluating the effects of an essential oil mixture (EOM), experimental essential oil mixture (EXP), tylosin, and monensin (MON) on feedlot cattle performance. The EOM contained thymol, eugenol, vanillin, guaiacol, and limonene (Benchaar et al., 2007). The EXP contained guaiacol, linalool, and α-pinene (Meyer et al., 2009). Treatments consisted of 1) control, no additives (CON); 2) EOM, 1.0 g/d; 3) EXP, 1.0 g/d; 4) EOM plus tylosin (EOM+T); and 5) monensin plus tylosin (MON+T). Compared to CON, DMI and ADG were not statistically different from steers fed EO. There was a tendency ($P \leq 0.10$) for an improvement in G:F for treatments EOM and EXP compared to CON, which was due to the numerical difference observed in ADG for these treatments. Steers fed EOM+T treatment had greater USDA yield grade compared to other treatments, however; other carcass characteristics were not affected by treatment. Total liver abscesses were reduced by 39.0% in the EOM treatment compared to the CON, but the EXP treatment was similar to CON. Monensin plus tylosin reduced the severity of liver abscesses compared to CON, EOM, and EXP treatments.

A commercial mixture of EO (Vertan®) at levels of 2 or 4 g/d was evaluated by Benchaar et al. (2006) with steers being fed 75% grass/legume silage and 24% rolled barley diet. With the addition of increasing doses of EO, DMI was not different from the control, however supplementation of EO showed a quadratic effect on feed efficiency with G:F being greatest when dosing 2 g/d of a mixture of EO. In another study, Chaves et al. (2008a) reported the effects of EO on lamb performance and carcass characteristics. Supplementation with GAR or CIN had no effect on DMI, but ADG was greater for lambs fed CIN compared to the control diet. Feed:gain was numerically improved for lambs fed CIN compared to those fed GAR and control. Addition of either CIN or GAR had no effect on carcass characteristics. The lack of effect of EO on intake is further supported by Chaves et al. (2008b) where they observed no difference in DMI when lambs were fed either barley or corn grain based diets and supplemented with 0.2 g/kg of CIN.

Monensin

Characterizing Monensin

The use of antibiotics, such as ionophores, have gained wide acceptance throughout the cattle feeding industry in the United States. Ionophores include lasalocid, tetronasin, lysocellin, narasin, laidlomycin, and monensin, which is the most commonly used (Russell and Strobel, 1989). Since the approval of monensin in feedlot diets in 1975, many experiments have been conducted evaluating its effects on feedlot performance.

Monensin, a product of fermentation, was first discovered and isolated from a strain of bacterium *Streptomyces cinnamonensis* in 1967 (Haney and Hoehn, 1967). The use of monensin, which is marketed under the product name Rumensin® (Elanco Animal Health, Greenfield, IN) has been approved by the U.S. Food and Drug Administration (FDA) for the use in cattle fed in confinement for slaughter, dairy cows, growing cattle on pasture or in dry lot, mature reproducing beef cows, calves (excluding veal calves), and goats. Label claims include improved feed efficiency, increased milk production efficiency, and the prevention and control of coccidiosis due to *Eimeria bovis*, *E. zuernii*, *E. crandallis*, *E. christenseni*, and *E. ninakohlyakimovae*.

Rumen Fermentation. Utilizing *in vitro* and *in vivo* experiments, Richardson et al. (1976) evaluated the effects of monensin on rumen fermentation. Rumen fluid from concentrate-fed cattle were used as inoculum in multiple *in vitro* experiments testing monensin levels of 0.1, 0.25, 0.5, 1, 5, and 25 ppm. Similarly, rumen fluid from cattle fed a roughage diet was also evaluated *in vitro* but with levels 0, 1, and 5 ppm of monensin. Results from using rumen fluid from a concentrate ration showed an increase in total VFA production when monensin was dosed at levels of 1 ppm or less; propionic acid production was increased at all dosage levels. Furthermore, dosing monensin at levels greater than 1 ppm reduced the production of acetic, isovaleric and valeric acids. Rumen fluid from roughage fed cattle responded differently with total VFA production being unchanged. A reduction in acetic acid production was observed when dosing at 5 ppm, and an increase in production of propionic acid at dosage levels of 1 and 5 ppm of monensin was seen. Furthermore, they conducted an *in vivo* experiment evaluating increasing amounts (0, 25, 50, 100, 200, and 500 mg/steer daily) of monensin to cattle fed a high-concentrate diet. At dosage levels of monensin at 100 mg/head/day or greater, acetic acid and butyric acid decreased while the amount of propionic acid increased. These results are further supported by a 148-day feeding trial evaluating monensin at levels of 0, 100, and 500 mg/head/day. Monensin dosage had no effect on total VFA production but the proportions of individual acids changed. However, dosing monensin at levels of 100 and 500 mg/head/day decreased the molar proportions of acetic acid and butyric acid and increased the molar proportion of propionic acid from 31.9 to 41.0 and 43.5%, respectively. The authors concluded that a shift of molar proportion to more propionate and less acetic acid and butyrate, results in increasing the efficiency of feed energy that is available to the ruminant resulting in more energy available for metabolism.

Feedlot performance. Early work of Goodrich et al. (1976) summarized data from 29 university experiments that involved 3,042 steers and heifers evaluating the effects of monensin concentrations on feedlot performance and carcass characteristics. Concentration levels of monensin used were 0, 5, 10, 20, 25, 30, or 40 g/ton DM. Cattle fed 30 g/ton of monensin gained significantly slower than those fed 10 g/ton (1.08 vs 1.13 kg/d). Daily gain for cattle fed no monensin and 30 g/ton monensin were not different. Feed intake decreased as the level of monensin in the diet increased. Feed conversions (F:G) for monensin levels of 0, 5, 10, 20, 25, 30, and 40 g/ton were 7.89, 7.38, 7.41, 7.31, 7.08, 7.23, and 7.22 kg/d, respectively. Monensin concentration had no effect on carcass characteristics.

Goodrich et al. (1984) summarized 228 feedlot trials that included 11,274 head of cattle fed either control (no monensin) or monensin-containing diets. Cattle fed monensin-containing diets gained 1.6% faster, reduced intakes by 6.4%, and F:G was improved by 7.5% compared to control fed cattle. With standard deviations of 8.5, 5.0, and 6.5% for ADG, DMI, and F:G being reported, considerable variation was observed which allowed for construction of models in an attempt to explain feedlot cattle response to monensin. In trials where control cattle had poor ADG, daily gain was improved more with monensin than in trials where ADG was high for control fed cattle. This suggests that a greater response to monensin may be observed for cattle that are inefficient in converting feed to gain. In trials where DMI was low for cattle consuming the control diet, DMI for monensin-fed cattle was greater than controls. Where DMI was high for control cattle, monensin-fed cattle reduced intake. The greatest reduction in DMI was observed with a monensin concentration of 35.5 mg/kg DM. However, greater concentrations of monensin did not improve F:G compared to lower concentrations of monensin. In these trials, the range of monensin concentrations was 31.8 ± 7.5 mg/kg. Also noted was when control fed cattle had poorer feed conversions (F:G), improvements in F:G were greatest for monensin-fed cattle. Various trials evaluated the effects of monensin on carcass characteristics. Of these, a positive increase (0.61%) in rib-eye area resulted from adding monensin to the diet (76.9 vs 77.3 cm^2). Quality grade was negatively affected (0.69%) with the addition of monensin in the diet (12.0 vs 12.0); however, other carcass characteristics were minimally affected due to inclusion of monensin.

A 14-trial summary (Potter et al. 1985) from various feedlots throughout the United States summarized the effects of feeding monensin (33 mg/kg) on cattle performance. Concentrate levels varied from 60 to 87% of the diet with corn being the major energy source in most trials. Average initial body weight was 327 kg with weights ranging from 253 to 465 kg. Average DOF was 132-d with trial lengths varying from 84 to 223-d. Feeding monensin had no effect on ADG (1.34 vs 1.33 kg). The addition of monensin reduced DMI by 7.72% (8.72 vs 9.45 kg) resulting in improving feed conversions (F:G) by 8.62% over control fed cattle (6.61 vs 7.25 kg). The incidences of liver abscesses were unaffected with the use of monensin and were the only carcass measurement reported.

A meta-analysis evaluating the impact of monensin on cattle performance was conducted by Duffield et al. (2012). Data from 64 papers/reports containing 169 trials of weaned growing and finishing cattle performance were used. Monensin concentrations ranged from 3 to 98 mg/kg with a mean concentration of 28.1 mg/kg. Monensin increased ADG by 2.5%, reduced feed intake by 3%, and improved G:F by 6.4%. Meta-regression analyses were constructed in attempt to explain the response to monensin. In experiments where the control cattle had greater ADG (> 1.17kg/d), the effect of monensin on ADG was less. Also, diets that contained corn silage with monensin improved F:G greater and had a larger impact on reducing DMI compared to studies not containing corn silage in diets of both growing and finishing cattle. The authors hypothesized that the use of corn silage in finishing diets, higher in energy content, and with an increased amount of propionate from monensin, would cause more of an effect on DMI and have a less effect on gain. However, the data used in this analysis spanned over 40 years and with the feed data being unreliable, separation of corn silage diets was unattainable. They also observed a linear effect of monensin dose on F:G, DMI, and ADG. When monensin concentration was at greater concentrations, it had greater effects on improving F:G and reducing DMI; however, the effect on ADG was lesser as monensin dose increased.

Tylosin

Characterizing Liver Abscesses and Tylosin. High-grain diets are traditionally fed to feedlot cattle to maximize the available energy in order to produce efficient gains; however this can lead to problems such as acidosis if cattle are not well managed. Stock and Britton (1993) define acidosis to be an array of biochemical and physiological stresses caused by rapid production and absorption of ruminal organic acids and endotoxins when an animal over-consumes a meal of readily fermentable carbohydrates. Starches in the rumen that are rapidly fermented, along with the accumulation of organic acids can result in ruminal acidosis, rumenitis, and, subsequently, to liver abscesses. This increase in acids causes ruminal epithelial damage which allows for the entry of bacteria into the portal vein and the ability to gain access to the liver. Other factors associated with rumen epithelial damage have been from particles of feed that are sharp (barley spicules) and foreign feed objects (plastic and metal). Once the bacterium enters the portal circulation it becomes entrapped in the portal capillary system of the liver, leading to infection and abscess formation (Nagaraja and Lechtenberg, 2007).

Numerous studies have isolated anaerobic and facultative bacteria from liver abscesses of cattle with anaerobic bacteria being predominant. The primary etiologic agent of liver abscesses is *Fusobacterium necrophorum* (Nagaraja and Lechtenberg, 2007), which is an anaerobic gram-negative, rod-shaped bacterium. The second most frequently isolated bacteria is a facultative gram-positive, rod-shaped bacterium called *Arcanobacterium pyogenes* (Nagaraja and Lechtenberg, 2007). For the prevention and control of liver abscesses, five antibiotics (bacitracin methylene disalicylate, chlorotetracycline, oxytetracycline, tylosin, and virginiamycin) have been approved, with bacitracin being least effective and tylosin being most effective and widely used in feedlots in the United States (Nagaraja and Lechtenberg, 2007). In late 1973, the FDA approved the use of Tylosin, which is marketed under the trade name Tylan® (Elanco Animal Health, Greenfield, IN), in beef cattle with labeled claims for reduction of incidence of liver abscesses associated with *Fusobacterium necrophorum* and *Arcanobacterium pyogenes*. Tylosin is approved for inclusion in the diet at a rate of 8.82 to 11.03 mg/kg (8.8-11.1 g/ton DM) for an animal receiving an actual consumption of 60-90 mg/hd daily tylosin.

Effects on Feedlot Performance and Carcass Characteristics. In the United States, the leading cause of liver condemnation is liver abscesses (Nagaraja and Lechtenberg, 2007). This is a dramatic economic loss not only to the producer, but also to the packer. Liver abscesses can occur in all classes and ages of cattle, but ones of greatest economic significance occur in feedlot cattle consuming grain-fed diets. Nagaraja et al. (1996) reported occurrences of liver abscesses to be greatest in intensively-fed beef cattle in the United States, Canada, Europe, Japan, and South Africa. Incidence of liver abscesses can be as low as 1 to 2% to as high as 90 or 95% (Nagaraja and Chengappa, 1998). Brink et al. (1990) reported the prevalence of liver abscesses to range from 12 to 32% without the use of antimicrobials; however, with the use of tylosin, prevalence of liver abscesses range from 10.2 to 12.5% for heifers and steers, respectively (Davis et al., 2007).

Foster and Woods (1970) summarized data consisting of 2,522 animals evaluating the effect of liver abscesses on animal performance. They reported 24.8% (625 head) of livers were condemned at slaughter due to the presence of abscesses, and these cattle gained less, graded lower, and dressed lighter compared to cattle with healthy livers. Similar results were reported by Brown et al. (1973) where the incidence of liver abscesses was 23.1% for cattle fed no antimicrobials, thus lower gains and poorer feed conversions were observed compared to cattle fed either tylosin phosphate or tylsoin urea adduct (50, 75, or 100 mg/d). Brink et al. (1990) summarized data from 12 experiments including 566 individually fed cattle evaluating the prevalence of liver abscesses and reported liver abscesses in 28% of the cattle studied. Liver abscess data was collected using the following categorical system in which each liver was scored on the size and number of abscesses present in order to determine the severity of abscesses: 0 = no abscess, normal; A- = one or two small abscesses; A = two to four small active abscesses; A + = one or more large, active abscesses. They concluded that animal performance was only affected with the presence of liver scores (A+) compared to non-abscessed cattle. Cattle with liver scores (A+) resulted in decreased gains, poorer feed conversions, lighter HCW, and lower carcass yields compared to non-abscessed cattle. Brown et al. (1975) summarized data from four experiments (1829 head) that utilized medium and high concentrate diets and the overall incidence of liver abscesses were 56.2% (337/600 head) for cattle fed no antibiotics; conversely, feeding tylosin decreased the prevalence of abscesses to 18.6%.

A 40-trial summary conducted by Vogel and Laudert (1994) reported the effectiveness of tylosin for the control of liver abscesses in feedlot cattle. Rations consisted of high concentrate diets typical to the location where the trial was conducted. Steers were utilized in 30 trials, 9 trials with heifers, and one trial with a combination of steers and heifers. Without the use of tylosin, prevalence of liver abscesses was 28.9% and 24.9% for steers and heifers, respectively. Incidence of liver abscesses was reduced to 7.8% and 6.4% for both steers and heifers when tylosin was fed. Cattle fed tylosin gained 2.3% faster, were 2.6% more efficient in converting feed to gain, and also had increased dressing percent. Likewise, Potter et al. (1985) decreased the incidence of liver abscesses from 27 to 9% with the use of tylosin and these cattle gained 1.97% faster compared to non-tylosin fed cattle. This data would agree with Meyer et al. (2009) where the prevalence of liver abscesses decreased from 27.2 to 6.5% when tylsoin was included in the diet. Similar reductions in liver abscesses with the use of tylosin in the diet have been observed (Heinemann et al., 1978 and Pendlum et al., 1978).

Davis et al. (2007) summarized data that consisted of 20,455 steers and 9,103 heifers and the effects of liver abscess incidence on carcass characteristics. All cattle were fed a minimum of 96% concentrate diet along with tylosin included at 90 mg/d. Livers were scored 0, A-, A, and A+ with abscesses of A+ being further separated by the presence (AD) or absence (NO AD) of an adhesion. Incidence of liver abscess scores (0, A-, A, A+) were 87.5, 6.2, 2.5 and 3.8% for steers, respectively. Hot carcass weight was reduced by 3.2 and 13.3 kg for steers with liver scores of A+ NO AD and A+ AD. Loin muscle area was decreased by 2.19 cm^2 for A+ AD steers also. For heifers, percentages of liver abscesses (0, A-, A, A+) were 89.8, 5.9, 1.5, and 2.8%, respectively. Hot carcass weights were 13.2 kg lighter for heifers with scores of A+ AD compared to those of 0, A-, and A. The authors concluded that the severity of liver scores have a greater impact on reducing HCW but having no effect on quality grade.

Most recently Brown and Lawrence (2010) evaluated 76,191 carcasses within two databases. For qualification in database 1 (n = 3,936) cattle did not receive antimicrobials for the prevention of liver abscesses, while cattle in database 2 (n = 72,255) were presumed to be fed antimicrobials to minimize liver abscesses. Liver abscesses were scored similarly to the way previously described but with the exception of livers that were adhered to the gastrointestinal tract or diaphragm or both being classified as A+AD and livers with ruptured abscesses were labeled as A+OP. Cattle in database 1 included livers of being normal (53.2%) while prevalence of abscesses were 12.0, 8.9, 5.3, 13.1 and 3.5% for liver scores of A-, A, A+, A+AD, and A+OP, respectively. Cattle in database 2 displayed liver abnormality rates of A- = 4.6%, A = 2.3%, A+ = 1.8%, A+AD = 2.2%, A+OP = 1.3%, and cattle with normal livers were 81.9%. In database 1, carcasses with a score of A+AD resulted in lighter ($P < 0.05$) HCW compared to carcasses with normal livers (343.3 vs 350.4 kg). Carcass yield was lower ($P < 0.05$) for carcasses with liver abnormalities of A+OP (62.36%), A+AD (62.48%), A+ (62.74%), and A- (62.97%) compared to carcasses with normal liver (63.25%). In database 2, carcasses with liver abnormalities of A- (350.8 kg), A+ (348.0 kg), A+OP (341.9 kg), A+AD (339.2 kg) resulted in lighter ($P < 0.05$) HCW compared to carcasses with normal livers (352.9 kg). Abnormalities of A+AD, A+OP, A+, A, and A- resulted in less 12^{th}-rib subcutaneous fat, while liver scores of A+AD, A+OP, A+, and A- had less LM area compared to those of normal livers. Of the reviewed literature, the use of tylosin has been shown to decrease the severity and prevalence of liver abscesses.

Conclusion

Replacing the amount of corn in finishing diets with ethanol by-products has been well researched, and in many instances enhanced animal performance. The use of soyhulls in finishing diets has not been well studied and possibly has the potential to replace a portion of corn in the diet and achieve equal or greater performance in the feedlot. Also, the use of feed additives, such as monensin, have been shown to increase the likelihood of economic returns for producers by improving feed conversions; but the mixed social acceptance of using these antibiotics allows for use of alternatives to be researched. The objectives for this research were to 1) determine the optimum level of soyhulls, replacing corn, when fed with distillers grains, and 2) evaluate the effects of EO on animal performance and carcass characteristics of cattle fed finishing diets with or without monensin and tylosin.

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Effects of increasing soybean hulls in finishing diets with distiller's grains on performance and carcass characteristics[1]

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[1] A contribution of the University of Nebraska Agricultural Research Division, supported in part by funds provided through the Hatch Act. Additional funding provided by the Nebraska Soybean Board.

ABSTRACT

Two experiments evaluated the effects of soybean hulls (SBH) on animal performance and carcass characteristics in finishing diets containing distillers grains plus solubles. Dietary concentrations of SBH used were 0, 12.5, 25, and 37.5% of diet DM. In Exp. 1, 167 (395 ± 22 kg of BW) crossbred yearling steers were used in a randomized block design replacing dry-rolled corn (DRC) with pelleted SBH and fed for 117 d. The remainder of the diet consisted of 25% modified distillers grains plus solubles (MDGS), 15% corn silage, and 5% liquid supplement. As SBH concentration increased, DMI increased linearly ($P = 0.04$). Gains decreased linearly ($P < 0.01$) along with G:F ($P < 0.01$) in response to increasing concentrations of SBH. Hot carcass weight linearly decreased ($P < 0.01$) by 24 kg as SBH increased. The feeding value of SBH was 69.6 to 59.5% of corn and decreased when SBH increased from 12.5 to 37.5% of DM. In Exp. 2, a randomized block design utilized 160 (BW = 363 ± 16 kg) backgrounded steer calves in a 138 d finishing study. Dietary treatments of SBH were similar to Exp. 1; however, the meal form of SBH was used. Basal ingredients consisted of a 1:1 ratio of high-moisture corn (HMC) and DRC, 40% wet distillers grains plus solubles (WDGS), 8% sorghum silage, and 4% dry meal supplement. A tendency ($P = 0.09$) for a linear increase in ADG as dietary SBH increased was observed, but gain was greatest at the 12.5% concentration. Feed efficiency tended ($P > 0.12$) to respond quadratically as SBH concentration increased; with steers fed 12.5% SBH being 2.3% more efficient than 0% SBH fed cattle. The feeding value of SBH was greater than that of corn when SBH was included in the diet at 12.5 and 25%. Results were variable between experiments and may be related to

inclusion of distillers or cattle type. Feeding SBH at 12.5% of the diet with 40% WDGS; improved animal performance when replacing HMC and DRC in the diet.

Key Words: distillers grains, finishing cattle, soybean hulls

INTRODUCTION

In 2011, the USDA reported that 74.9 million acres of soybeans were planted producing over 3.0 billion bushels of soybeans (NASS, 2012). Of the total weight of the soybean, Sessa and Wolf (2001) reported the soybean hull represents eight percent of DM. Traditionally, the hull was blended with soybean meal resulting in 44% CP. Today, with poultry and swine industries combining to utilize 70 to 75% of soybean meal (American Soybean Association, 2011) and their limited ability to digest fiber (Kohlmeier, 1996), smaller quantities of soybean hulls (SBH) are blended back into soybean meal. Thus, more SBH are available to be used as cattle feed.

Supplementing SBH as an alternative energy source to cereal grains in forage diets has been shown to have an energy value equal to or greater than that of corn (Garcés-Yépez et al., 1997; Anderson et al., 1988). Similarly, Swanson et al. (2007) observed no difference in animal performance between SBH or corn included in backgrounding diets for beef cattle. Feeding SBH with a combination of wet corn gluten feed (WCGF) and wet distillers grains plus solubles (WDGS) to steers resulted in ADG and feed efficiency being poorest in finishing diets (Wilken et al., 2009). However, no data exist evaluating the effects of increasing concentrations of SBH, replacing corn, in finishing diets containing WDGS. Therefore, 2 experiments were conducted to determine the optimum concentration of SBH in a feedlot finishing diet with distillers grains and to assess the energy value of SBH relative to corn.

MATERIALS AND METHODS

All facilities and procedures were approved by the University of Nebraska Institutional Animal Care and Use Committee (IACUC 517 and 525).

Exp. 1

One-hundred sixty eight, crossbred yearling steers (395 ± 22 kg of BW) were utilized in a randomized block design study over a 117 d finishing trial. Steers were purchased at a local auction barn and received at the University of Nebraska-Lincoln Haskell Agricultural Laboratory (near Concord, NE) research feedlot during the fall of 2011. Initial processing included vaccination against *Infectious Bovine Rhinotracheitis, Bovine Virus Diarrhea, Parainfluenza-3, Bovine Respiratory Syncytial Virus, Mannheimia haemolytica, and Pasteurella multocida* (Vista Once SQ; Merck Animal Health, Summit, NJ), prevention of *Clostridium chauvoei, septicum, novyi, sordellii, and perfringens* (Vision 7; Merck Animal Health), administration of an insecticidal pour-on (Exile Ultra; Agripharm Products, Westlake, TX), and designation of a panel tag for identification. Steers were limit fed a diet consisting of 40% dry rolled corn (DRC), 20% modified distillers grains plus solubles (MDGS; ADM, Columbus, NE), 20% pelleted soybean hulls (SBH; ADM, Fremont, NE), 15% corn silage, and 5% supplement (DM basis) at 2% BW for four days to limit gut fill variation (Klopfenstein, 2011). Steers were weighed d 0 and 1, and then averaged to establish initial BW (Stock et al., 1983). Cattle were blocked by d 0 BW into three blocks (light, medium, heavy), stratified by

BW within block, and assigned randomly to one of 24 pens. Light, medium, and heavy weight blocks consisted of 2 replications each. Pens were assigned randomly to one of 4 treatments with 7 steers per pen and 6 replications per treatment.

Dietary treatments (Table 1) consisted of SBH fed at 0, 12.5, 25, or 37.5% diet DM while replacing dry-rolled corn (DRC). Cattle were adapted to a high energy concentrate diet over a 25 d period prior to limit feeding; therefore, cattle were fed their respective finishing diet on d 1. All finishing diets included 25% MDGS, 15% corn silage, dry-rolled corn (DRC), and 5% liquid supplement (Feed Commodities Co., Fremont, NE). The liquid supplement was formulated to provide 31.9 mg/kg monensin and 90 mg/steer daily tylosin, respectively (Elanco Animal Health, Greenfield, IN).

Cattle were fed once daily at approximately 0800. Bunks were evaluated daily and managed so that only trace amounts of feed were present at time of feeding. When refusals were present; orts were weighed, sampled, frozen and later analyzed for DM. Dry matter was determined by placing samples in a 60°C forced-air oven for 48 h (AOAC Method 935.29). Soybean hulls were sampled monthly, composited, and used for subsequent analysis. Ingredient CP was analyzed using a combustion chamber (AOAC, 990.03; TruSpec N Determinator, Leco Corporation, St. Joseph, MI). Ingredient NDF was determined by using the procedure defined by Van Soest et al. (1991). Ether extract was determined by performing a biphasic lipid extraction procedure described by Bremer (2010). The nutrient composition of SBH was 57% NDF, 13.2% CP, and 3.8% ether extract.

Steers were implanted with Revalor-S (Merck Animal Health) on d 0 and harvested on d 118 at Greater Omaha Packing Co., (Omaha, NE). Hot carcass weight and liver scores were recorded on d 118. After a 48 h chill, USDA marbling score, 12th rib fat depth, and LM area were recorded. A common dressing percentage of 63% was used to calculate carcass adjusted performance to determine final BW, ADG, and G:F. A constant KPH of 2.5% was assumed and used in the USDA yield grade calculation of Boggs and Merkel (1993). At the 0% SBH inclusion, one steer died from an umbilical abscess.

The NRC (1996) model was used to predict animal performance based on dietary energy content and intake. With input variables of diet composition, initial BW, final BW, ADG, and DMI known, the energy value of SBH relative to corn was calculated for each treatment. Total digestible nutrients were assumed to be 90% for corn (NRC, 1996), 72% for corn silage (NRC, 1996), and 112.5% for MDGS (Bremer, 2010) in all diets. The net energy (NE) adjusters for the 0% concentration were adjusted to equal observed ADG for that treatment. The NE adjusters were held constant for evaluation of SBH treatments (79%). With NE adjusters held constant, the percent TDN value for soyhulls was adjusted until the observed ADG for each pen was obtained using observed DMI. The energy value was then calculated by taking the percent TDN value of SBH divided by percent TDN of corn for each treatment.

The feeding value (Bremer, 2010) of SBH relative to corn was also calculated for each concentration of SBH using feed efficiency. The difference between each SBH concentration and the 0% treatment were calculated, divided by the feed efficiency of the 0% SBH, then divided by the decimal percentage of concentration of SBH, and multiplied by 100 to get a feeding value relative to corn for each SBH concentration.

Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C). Pen was the experimental unit and block was treated as a fixed effect. Orthogonal contrasts were constructed to determine the response curve (linear, quadratic, and cubic) for SBH concentration in the diet.

Exp. 2

One hundred sixty, backgrounded steer calves (BW = 363 ± 16 kg) were utilized in a randomized block design. The 138 d finishing trial was conducted at the University of Nebraska Agricultural Research and Development Center (near Mead, NE) in the spring of 2012. Cattle were received into feedlot pens and utilized in a 30 d receiving study. After the receiving study, steers were placed on a common diet consisting of Sweet Bran (Cargill Corn Milling, Blair, NE.), cornstalks, and wheat straw for 15 d. Initial processing included the vaccination against *Infectious Bovine Rhinotracheitis, Bovine Viral Diarrhea, Parainfluenza-3, Bovine Respiratory Syncytial Virus* (Bovi-Shield GOLD 5; Pfizer Animal Health; New York, NY), prevention of *Haemophilus somnus* (Somubac; Pfizer Animal Health), *Mannheimia Haemolytica* (One Shot; Pfizer Animal Health), administration of a paraciticide injection (Dectomax; Pfizer Animal Health), and individual identification (panel tag, metal tag, and electronic ear button). Approximately 2 weeks later, cattle were revaccinated with Bovi-Shield GOLD 5 (Pfizer Animal Health), Vision 7 (Merck Animal Health), and *Moraxella Bovis* (Piliguard Pinkeye Triview; Merck Animal Health). Prior to initiation of trial, steers were limit fed at 2% BW a diet consisting of 50% Sweet Bran and 50% alfalfa hay for 5 d to minimize variation in gastrointestinal fill. Cattle were weighed and assigned randomly to one of 20 pens using the same method as described in Exp. 1. Light, medium, and heavy blocks consisted of 1, 2, and 2 replications, respectively. Pens were assigned randomly to one of four treatments with 8 steers per pen and five pens per treatment.

Dietary treatments (Table 2) consisted of ground SBH (Bunge, Council Bluffs, IA) at 0, 12.5, 25, and 37.5% diet DM while replacing a 1:1 blend of DRC and high-moisture corn (HMC). All finishing diets contained 40% wet distillers grains plus solubles (WDGS; BioFuel Ethanol Energy Corp., Wood River, NE), 8% sorghum silage, and 4% dry meal supplement. The supplement was formulated for 33 kg/mg of monensin (Rumensin, Elanco Animal Health) and 90 mg/steer daily of tylosin (Tylan, Elanco Animal Health). Adaptation to the final finishing diets consisted of a 17 d period and four adaptation diets fed 3, 4, 5, and 5 d, respectively, by increasing the inclusion of corn blend and SBH, while decreasing the level of sorghum silage in the diet. For step 1, sorghum silage was fed at 35% of DM and decreased by 7% for each subsequent step, except by 6% when transitioning from step 4 to the finisher diet. For steers fed 12.5% SBH, step 1 consisted of SBH at 5.5% of DM then increasing to 12.5% at step 2. Soybean hulls were introduced at 20% of DM in step 1 for treatment groups 25 and 37.5% SBH. For steers fed 25% SBH, step 2 included SBH at 25% of DM. Soybean hulls were increased by 8, 7, and 2.5% of DM during steps 2, 3, and 4 for steers fed 37.5% SBH. In all treatments, the supplement for step 1 was provided at 5% DM of the diet, but was included at 4% throughout the remainder of the feeding period. Wet distillers grains plus solubles was included in the diet at 40% of DM in all steps. Bunks were evaluated daily at 0600 for the presence of feed and managed as described in Exp. 1 with steers being fed once daily at approximately 0800. Feed refusals were weighed, sampled, and dried in a forced-air oven for 48 h at 60°C for DM determination (AOAC

Method 935.29). Soybean hulls and ingredients were sampled weekly, composited by month, and subsequent analyses were performed as described in Exp. 1. The nutrient composition of SBH was 58% NDF, 12.9% CP, and 3.7% ether extract.

Steers were implanted on d 1 with Revalor-IS (Merck Animal Health), re-implanted with Revalor-S (Merck Animal Health) on d 47, and harvested at Greater Omaha Pack (Omaha, NE) on d 139. Carcass measurements were taken in the same manner as described in Exp. 1. Two steers died due to bloat, one fed 0% and one fed 37.5% SBH; two steers were removed from the study (one each on 25 and 37.5% SBH) due to chronic bloating.

The energy values and feeding values of SBH relative to corn were calculated in the same manner as described in Exp. 1. Total digestible nutrients were assumed to be 90% for DRC (NRC, 1996), 93% for HMC (NRC, 1996), 60% for sorghum silage (NRC, 1996), and 117% for WDGS (Bremer, 2010) in all diets. The net energy (NE) adjusters for the 0% diet were adjusted to equal observed ADG for that treatment. The NE adjusters were set at 77.6% based on performance of the 0% diet. Treatments were then evaluated where TDN of SBH was modified to equal observed ADG after setting observed DMI.

Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C) with removed animals (dead or chronic) not included in the analysis. Pen was the experimental unit and block was treated as a fixed effect. Orthogonal contrasts were constructed to determine the response curve (linear, quadratic, and cubic) for SBH concentration in the diet. Treatment differences were considered significant at $P \leq 0.05$.

RESULTS

Exp. 1

As SBH concentration increased, DMI decreased linearly (Table 3; $P = 0.04$) and tended to increase quadratically ($P = 0.10$). As dietary concentration of SBH increased from 0 to 37.5%, DMI decreased from 12.2 kg/d to 11.7 kg/d. Average daily gain decreased linearly ($P < 0.01$) as SBH replaced corn. A 4.3% decrease in ADG was observed between 0% and 12.5% SBH, and a 17.5% decrease between 0% and 37.5% SBH. Gain efficiency decreased linearly ($P < 0.01$) as concentration of SBH increased with steers being fed 0% SBH being most efficient. A 3.9% reduction in G:F was observed from 12.5 to 25% SBH and a 8.2% decrease in efficiency was noted when comparing 25 and 37.5% SBH. Replacing corn with SBH resulted in poorer gains; correspondingly, final BW decreased linearly ($P < 0.01$). Steers fed 37.5% SBH were 39 kg lighter than those fed 0% SBH. For carcass characteristics, HCW decreased linearly ($P < 0.01$; Table 3) as inclusion of SBH in the diet increased, with steers fed 0% SBH having 24 kg heavier carcasses than those fed 37.5% SBH. Concentration of SBH had no effect on LM area ($P > 0.31$) or 12th rib fat ($P > 0.77$). There was a trend ($P = 0.07$) for a linear decrease in marbling score as SBH concentration increased. Calculated YG decreased linearly ($P < 0.01$) as SBH increased in the diet.

The energy value (Table 3) of SBH relative to corn was calculated using the NRC (1996). The calculated energy value (% of corn) of SBH numerically decreased as SBH concentration increased. When feeding 12.5% SBH, the greatest (91%) energy value was calculated. The lowest (79%) calculated energy value was observed when feeding 37.5% SBH in finishing diets. The feeding value (%; Table 3) of SBH relative to corn was calculated for each concentration using G:F. The greatest feeding value

(69.6%) was calculated when SBH were included in the diet at 12.5 and 25% DM, respectively. When dietary concentration of SBH was 37.5%, the feeding value of SBH decreased to 59.5%.

Exp. 2

The inclusion of SBH in the diet had no effect ($P > 0.17$; Table 4) on DMI. There was a tendency ($P < 0.09$) for a linear decrease in ADG as concentration of SBH increased in the diet. Numerically, response in ADG appeared quadratic ($P = 0.12$) with greatest gains (1.83 kg/d) being observed at 12.5% SBH resulting in 3.8 and 9.2% greater gains compared to concentrations 0 and 37.5%, respectively. Gain efficiency tended to respond quadratically ($P = 0.12$) with steers fed 12.5% SBH being 2.3% more efficient than 0% SBH, then slightly decreasing at the 25% concentration; however, numerically steers fed 25% SBH were still 1.8% more efficient than those fed 0% SBH. A 3.4% reduction in efficiency was also observed between 25 and 37.5% SBH.

Final BW and HCW tended to decrease linearly ($P = 0.12$) as concentration of SBH increased. With increasing concentrations of SBH, 12^{th} rib fat thickness decreased linearly ($P = 0.04$; Table 4) from 1.52 cm to 1.24 cm for SBH concentrations 0 and 37.5%, respectively. Calculated yield grade tended ($P = 0.06$) to decrease linearly as dietary SBH increased. An effect of SBH on marbling score and LM area ($P > 0.34$) was not detected.

Using the NRC (1996), the energy value (Table 4) of SBH relative to corn was calculated. The calculated energy value was lowest (99%) when SBH concentration was 37.5% DM. When dietary concentration of SBH was 25% DM, a 107% energy value was calculated. By decreasing the concentration of SBH to 12.5% DM, the energy value of SBH was 106%. The feeding value (Table 4) of SBH (as % of corn) was calculated for each concentration by using G:F. When feeding SBH at 12.5% DM, the feeding value relative to corn was greatest (118.7%). Intermediate (107.0%) feeding value was observed when SBH concentration was 25% of DM. When SBH was included in the diet at 37.5% DM, lowest (95.3%) feeding value was calculated.

DISCUSSION

Explanation for the cattle that died and were removed from Exp.2 is unclear because bloat was experienced with steers fed 0, 12.5, and 37.5% SBH. However, previous research when feeding SBH has shown to increase the occurrence of bloat (Shriver et al., 2000; Steele et al., 2001). In Exp. 1, steers fed increasing concentrations of SBH resulted in a linear decrease in DMI; however, previous research by Ludden et al. (1995) replacing corn with SBH (0, 20, 40, or 60% of diet DM) in finishing diets and observed a linear increase in DMI. Previous work by Hsu et al. (1987) for cattle fed SBH at concentrations of 25 or 50% diet of DM observed minimal differences in DMI. Cattle in Exp. 2 responded similar to work by Hsu et al. (1987) where DMI was not impacted. In Exp. 1, ADG decreased linearly and poorer responses in feed efficiency were observed as SBH concentration increased, similar to the observation of Ludden et al. (1995). Numerically, gains were greatest for steers fed 12.5% SBH in Exp. 2, similar to the observation of Anderson and Schoonmaker (2005). Feed efficiency tended to respond quadratically in Exp. 2, with greatest G:F observed at the 12.5 and 25% SBH inclusion then decreasing at 37.5%, which was not different from 0%. Comparable results were observed by Bunyecha (2005) when they replaced corn with SBH (0, 25, 50, and 75%

DM basis) and observed no difference in G:F at SBH inclusion levels of 0, 25, or 75%, respectively.

The 1996 NRC reports the energy value (TDN) of SBH to be 80%, which is 89% of corn (90% TDN). Our findings would suggest the energy value to be 79 to 107% that of corn, depending on the concentration of SBH. In the current studies, the feeding value of SBH was greater than that reported by Ludden et al. (1995). The calculated energy value of SBH relative to corn decreased as concentration of SBH increased and this was observed in both experiments. However, the major differences observed between Exp. 1 and 2 for the feeding and energy value of SBH is unclear. Possible differences could be partially attributed to the location of the study, cattle type (calf fed vs yearling steers), the form of SBH used in the diet, or the type and level of distillers grains used. Previous work of Bremer (2010) reported that when including distillers grains at 10 to 40% of diet, the feeding value relative to corn were 150 to 130 and 128 to 117 (DM basis) for WDGS and MDGS, respectively. In Exp. 1, MDGS was included in the diet at 25% DM, and Exp. 2, WDGS at 40% DM was included. Collectively, feedlot location, cattle type, and energy value of distillers grains could be all contributing to the animal performance differences observed.

IMPLICATIONS

Both feeding and energy values of SBH relative to corn was greater when fed in combination with WDGS than in diets with MDGS. Replacing corn with 12.5% SBH in finishing diets improves animal performance when fed with WDGS, but the price of SBH relative to corn is critical for economics and optimizing use.

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TABLES

Table 1. Composition for diets fed to finishing steers (Exp. 1).

	Treatment[1], % of diet DM			
Item	0SBH	12.5SBH	25SBH	37.5SBH
Dry-rolled corn	55.0	42.5	30.0	17.5
Modified distillers grains solubles	25.0	25.0	25.0	25.0
Soybean hulls (SBH)	--	12.5	25.0	37.5
Corn Silage	15.0	15.0	15.0	15.0
Liquid Supplement[2]	5.0	5.0	5.0	5.0

[1]0SBH = 0% SBH diet, 12.5SBH = 12.5% SBH diet, 25SBH = 25% SBH diet, 37.5SBH = 37.5% SBH diet.
[2]Supplement formulated to provide 31.9 mg/kg monensin and 90 mg/steer daily of tylosin (Elanco Animal Health, Greenfield, IN).
Supplement contained minimum 15% CP, 8.0% Ca, 3.0% K, 2.0% salt, 0.21% P, 0.01% crude fat, 0.01% crude fiber.
Supplement contained maximum 9.0% Ca and 3.0% salt.
Supplement contained 6,182 IU of vitamin A, 1,227 IU of vitamin D, 1.5 IU of vitamin E/kg .

Table 2. Composition for diets fed to finishing steers (Exp. 2).

	Treatment[1], % of diet DM			
Ingredient, %	0SBH	12.5SBH	25SBH	37.5SBH
Dry-rolled corn	24.00	17.75	11.50	5.25
High-moisture corn	24.00	17.75	11.50	5.25
Wet distillers grains solubles	40.00	40.00	40.00	40.00
Soybean hulls (SBH)	--	12.50	25.00	37.50
Sorghum Silage	8.00	8.00	8.00	8.00
Dry Supplement[2]				
Fine ground corn	2.0595	2.0595	2.0595	2.0595
Limestone	1.4250	1.4250	1.4250	1.4250
Salt	0.3000	0.3000	0.3000	0.3000
Tallow	0.1250	0.1250	0.1250	0.1250
Beef trace mineral[3]	0.0500	0.0500	0.0500	0.0500
Vitamin A-D-E[4]	0.0150	0.0150	0.0150	0.0150
Rumensin-90[5]	0.0165	0.0165	0.0165	0.0165
Tylan-40[6]	0.0090	0.0090	0.0090	0.0090
Analyzed Nutrient Composition				
NDF	22.7	28.6	34.6	40.5
Crude Protein	16.6	17.1	17.6	18.2
Ether Extract	5.2	5.2	5.2	5.2

[1]0SBH = 0% SBH diet, 12.5SBH = 12.5% SBH diet, 25SBH = 25% SBH diet, 37.5SBH = 37.5% SBH diet.
[2]Supplement formulated to be fed at 4% of diet DM
[3]Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, 0.05% Co.
[4]Premix contained 1,500 IU of vitamin A, 3,000 IU of vitamin D, 3.7 IU of vitamin E·g^{-1}.
[5]Premix contained 198 g monensin·kg^{-1}.
[6]Premix contained 88 g tylosin·kg^{-1}.

Table 3. Effect of Soybean hull inclusion on finishing cattle performance and carcass characteristics (Exp. 1).

Item	Treatment[1]				SEM	*P-value*	
	0SBH	12.5SBH	25SBH	37.5SBH		Lin.[2]	Quad.[3]
Performance							
Initial BW, kg	394	395	396	396	2	0.23	0.92
Final BW, kg[4]	619	609	604	580	11	<0.01	0.19
DMI, kg /d	12.2	12.1	12.2	11.7	0.2	0.04	0.10
ADG, kg	1.91	1.83	1.78	1.58	0.10	<0.01	0.19
G:F	0.158	0.152	0.146	0.134	0.003	<0.01	0.37
Energy Value[5], %		91	86	79			
Feeding Value[6],%		69.6	69.6	59.5			
Carcass Characteristics							
HCW, kg	390	384	381	366	7	<0.01	0.18
Marbling[7]	591	585	564	566	11	0.07	0.75
LM area, cm^2	83.55	84.64	84.06	82.58	1.23	0.54	0.31
12^{th} rib fat, cm	1.24	1.19	1.22	1.22	0.08	0.78	0.82
Calculated YG[8]	3.48	3.29	3.20	2.98	0.11	<0.01	0.90

[1]0SBH = 0% SBH diet, 12.5SBH = 12.5% SBH diet, 25SBH = 25% SBH diet, 37.5SBH = 37.5% SBH diet.

[2]Lin. = P-value for the linear response to Soyhulls inclusion.

[3]Quad. = P-value for the quadratic response to Soyhulls inclusion.

[4]Calculated from carcass weight, adjusted to 63% common dressing percent.

[5] Percent relative to corn, calculated from percent TDN of soyhulls, divided by percent TDN of corn (90%).

[6]Percent of corn feeding value calculated as percent different in G:F from control divided by inclusion.

[7]Marbling Score: 400 = Slight, 500 = Small, 600 = Modest, etc.

[8]YG = 2.50 + (6.35*fat thickness, cm) + (0.2*KPH,%) + (0.0017*HCW, kg) – (2.06*LM area, cm^2).

Table 4. Effect of Soybean hull inclusion on finishing cattle performance and carcass characteristics (Exp.2).

	Treatment[1]					*P-value*	
Item	0SBH	12.5SBH	25SBH	37.5SBH	SEM	Lin.[2]	Quad.[3]
Performance							
Initial BW, kg	359	359	360	360	0.45	0.20	0.64
Final BW, kg[4]	601	611	601	591	5.9	0.12	0.13
DMI, kg/d	10.3	10.5	10.0	10.0	0.2	0.18	0.57
ADG, kg	1.76	1.83	1.75	1.67	0.04	0.09	0.12
G:F	0.171	0.175	0.174	0.168	0.003	0.45	0.12
Energy Value[5], %		106	107	99			
Feeding Value[6], %		118.7	107.0	95.3			
Carcass Characteristics							
HCW, kg	379	385	378	372	3.6	0.12	0.13
Marbling[7]	580	573	573	565	18	0.57	0.99
LM area, cm^2	82.84	83.35	83.74	84.90	1.55	0.35	0.83
12^{th} rib fat, cm	1.52	1.35	1.32	1.24	0.10	0.04	0.61
Calculated YG[8]	3.58	3.43	3.33	3.19	0.13	0.06	0.98

[1]0SBH = 0% SBH diet, 12.5SBH = 12.5% SBH diet, 25SBH = 25% SBH diet, 37.5SBH = 37.5% SBH diet.

[2]Lin. = P-value for the linear response to Soyhulls inclusion.

[3]Quad. = P-value for the quadratic response to Soyhulls inclusion.

[4]Calculated from carcass weight, adjusted to 63% common dressing percent.

[5] Percent relative to corn, calculated from percent TDN of soyhulls, divided by percent TDN of blend drc:hmc (91.5%).

[6]Percent of corn feeding value calculated as percent different in G:F from control divided by inclusion.

[7]Marbling Score: 400 = Slight, 500 = Small, 600 = Modest, etc.

[8] YG = 2.50 + (6.35*fat thickness, cm) + (0.2*KPH,%) + (0.0017*HCW, kg) – (2.06*LM area, cm^2).

Including NEXT ENHANCE essential oils in finishing diets on performance with or without monensin and tylosin[1]

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[1] A contribution of the University of Nebraska Agricultural Research Division, supported in part by funds provided through the Hatch Act.

ABSTRACT

A finishing study was conducted evaluating the effects of NEXT ENHANCE (NEX) and monensin/tylosin (MT) on feedlot performance, carcass characteristics, and liver abscesses in finishing diets. Four hundred calf fed steers (BW= 291 ± 29 kg) were utilized in a randomized block design (n=3 BW blocks) using a 2 x 2 factorial treatment structure. Factors included the presence or absence of NEX and presence or absence of MT resulting in 4 treatments: 1) control, no additives (CON); 2) NEX; 3) MT; and 4) NEX plus MT. The essential oils (NEX) were included at 300 mg/steer daily, monensin at 360 mg/steer daily and tylosin at 90 mg/steer daily. A common basal diet was used for all four treatments consisting of 53% dry-rolled corn, 25% wet distillers grains plus solubles, 16% corn silage, and 6% supplement (DM basis). Steers were fed for either 141 or 161 d based on BW block. There were no significant MT x NEX interactions ($P >$ 0.05) for finishing performance or carcass characteristics. There was a tendency ($P =$ 0.07) for cattle fed MT to have improved ADG, while feeding NEX had no effect ($P =$ 0.85). In diets containing MT, a 3.9% improvement in G:F ($P < 0.01$) was observed but when feeding NEX, G:F was not affected ($P > 0.86$). There was a trend ($P = 0.07$) for an increase in HCW and a significant ($P < 0.01$) increase in marbling score when steers were fed MT. Incidence of liver abscesses decreased 45.7% when MT ($P < 0.01$) was fed compared with diets that did not contain MT. Feeding NEX did not statistically impact ($P > 0.74$) carcass characteristics. The prevalence of liver abscesses decreased with the addition of MT and G:F improved when MT was included in the diet. Feeding NEX with or without MT had no impact on feedlot performance and carcass characteristics.

Key Words: essential oil, feedlot cattle, liver abscesses

INTRODUCTION

High-grain diets are traditionally fed to feedlot cattle to maximize the available energy and produce efficient gains. Overconsumption of readily fermentable carbohydrates can lead to a rapid production and absorption of ruminal organic acids and endotoxins, causing the animal to become acidotic (Stock and Britton, 1993), which can lead to rumenitis and subsequent liver abscess formation.

The use of monensin (Rumensin®; Elanco Animal Health, Greenfield, IN), an ionophore, has been widely accepted in feedlots since its approval in 1975. Previous research with the addition of monensin has shown to reduce feed intake (Goodrich et al., 1984; Duffield et al., 2012), improve feed efficiency (Potter et al., 1985), reduce feed intake variation (Stock et al., 1995), and acidosis (Erickson et al. 2003).

Tylosin (Tylan®; Elanco Animal Health, Greenfield, IN) has been approved for the prevention and control of liver abscesses in beef cattle caused by *Fusobacterium necrophorum* and *Arcanobacterium pyogenes* (Nagaraja and Lechtenberg, 2007). Feeding tylosin decreases liver abscesses, increases ADG, and increases G:F (Brown et al. 1973; Vogel and Laudert, 1994; Potter et al. 1995). Monensin and tylsoin are commonly fed in combination. Feeding monensin plus tylosin reduces DMI (Stock et al., 1995; Meyer et al., 2009), increases ADG (Stock et al., 1995) and improves G:F (Stock et al.,1995; Meyer et al., 2009); however, no affect on ADG and feed efficiency was observed by Galyean et al. (1992).

Essential oils are secondary plant metabolites that can be extracted from plant tissues with the use of steam distillation or organic-solvents (Wallace, 2004; Calsamiglia et al., 2007). Secondary plant metabolites have been shown to have ruminal antimicrobial activity (Cowan, 1999) against gram-positive and gram-negative bacteria. *In vitro* studies with essential oils have demonstrated decreases in proportion of acetate to propionate during ruminal fermentation (Busquet et al., 2005; Busquet et al., 2006). Feeding essential oils has shown to reduce DMI (Yang et al., 2010) and improved G:F (Benchaar et al., 2006; Meyer et al., 2009); however, few feedlot growth studies have been conducted to support this improvement. Therefore, the objective of this experiment was to evaluate the effects of NEXT ENHANCE (Novus International, Inc., St. Charles, MO) essential oils on performance and carcass characteristics of cattle fed finishing diets with or without monensin and tylosin.

MATERIALS AND METHODS

All facilities and procedures were approved by the University of Nebraska Institutional Animal Care and Use Committee. (IACUC 631)

Four hundred calf fed steers (BW= 291 ± 29 kg) were utilized in a randomized block design experiment. Steers were received at the University of Nebraska Panhandle Research and Extension Center feedlot (near Scottsbluff, NE) in the fall of 2011 over a 3 d period. Within 24 hours of arrival, cattle were processed and vaccinated with Bovi-Shield Gold 5 (for the prevention of IBR, BVD Types I & II, PI3, and BRSV; Pfizer Animal Health, New York, NY), Vision 7 (for the prevention of Clostridium chauvoei, septicum, novyi, sordellii, perfringens Types C & D; Merck Animal Health, Summit, NJ), Somubac (for the prevention of Haemophilus somnus; Pfizer Animal Health), poured with an ivermectin paraciticide (Ivomec; Merial, Duluth, GA), branded, and given an electronic and visual identification tag. On d 9, all steers were re-vaccinated with Bovi-Shield Gold 5, Somubac, and given an initial implant Component TE-IS (Elanco Animal Health, Greenfield, IN). Steers were re-vaccinated again on d 51 with Express 5 (for the prevention of IBR, BVD Types I & II, PI3, and BRSV; Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO). Cattle were re-implanted with Component TE-S (Elanco Animal Health) and re-vaccinated with Vision 7 on d 79. Prior to initiation of trial, steer calves were limit fed a 50% alfalfa, 35% corn silage, and 15% wet distillers grains plus solubles (WDGS; Colorado Agri Products, Bridgeport, NE) diet (DM basis) at 2% of BW for seven days to minimize gut fill variation (Klopfenstein, 2011). Steers were weighed on days 0 and 1 to establish initial BW (Stock et al., 1983), blocked by day 0 BW, stratified within blocks (light, medium, heavy), and assigned randomly to 40 pens. Pens were assigned randomly to one of four treatments with 10 replications (i.e. pen) per treatment and 10 steers per pen. Light, medium, and heavy blocks consisted of 3, 5, and 2 replications, respectively.

A 2 x 2 factorial arrangement of treatments was used with one factor being the presence or absence of NEXT ENHANCE (Novus International, Inc., St. Charles, MO), and the other factor being presence or absence of monensin (Rumensin, Elanco Animal Health) plus tylosin (Tylan, Elanco Animal Health). The ingredients of NEXT ENHANCE are calcium carbonate, rice hulls, cinnamaldehyde, silica, mono and diglycerides of fatty acids, garlic oil, and mineral oil. Cattle were adapted to a common finishing diet over a 21 d period consisting of 4 steps. The amount of WDGS and supplement included in each step was held constant at 25 and 6% (DM basis), respectively. The amount of corn was gradually introduced in the diet while replacing the amount of alfalfa hay and corn silage. The first adaptation ration consisted of 32% corn silage, 20% alfalfa hay, and 17% dry-rolled corn (DRC) and was fed for 3 d. The second adaptation diet was fed for 4 d and consisted of 28% corn silage, 14% alfalfa hay, and 27% DRC. The third adaptation step was fed for 7 d and consisted of 24% corn silage, 8% alfalfa hay, and 37% DRC. The fourth and final adaptation diet was fed for 7 d and consisted of 20% corn silage, 4% alfalfa hay, and 45% DRC. A common basal diet was used for all four treatments (Table 1) for the remainder of the finishing period and consisted of 53% dry rolled corn, 25% WDGS, 16% corn silage, and 6% supplement (DM basis). Only one basal supplement was used and feed additives were included via micro-machine (Lextron Animal Health, Garden City, KS). Treatments consisted of a control containing no additives (CON), NEXT ENHANCE formulated at 300 mg/d (NEX), monensin plus tylosin formulated at 360 and 90 mg/d, respectively (MT), or NEXT ENHANCE formulated at 300 mg/d plus monensin (360 mg/d) and tylosin (90 mg/d; NEXMT).

Feed bunks were assessed daily at approximately 0700 for presence of feed. Bunks were managed daily so that only trace amounts of feed were present at time of feeding and refused feed was removed as needed, weighed, sampled, and dried in a forced-air oven for 48 h at 60°C for DM determination (AOAC Method 935.29), to obtain accurate DMI. Cattle were fed once daily at 0800. Individual ingredient samples were taken weekly and analyzed for DM content. Weekly ingredient samples were composited for the entire feeding period, with one sample of each ingredient being sent to a commercial laboratory (Servi-Tech Laboratories, Hastings, NE) for analysis of DM (AOAC, 930.150), NDF (Ankom Technology, Fairport, NY), CP (AOAC, 990.03), crude fat (Soxtec System HT 6), Ca, P, K, S, and starch (Xiong, et al., 1990). The nutrient composition for DRC used in this study was 84.9% DM, 9.6% NDF, 8.5% CP, 3.2% crude fat, < 0.01% Ca, 0.26% P, 0.30% K, 0.09% S, and 70.9% starch (DM basis). The WDGS used was 34.3% DM, 40.4% NDF, 30.2% CP, 11.0% crude fat, 0.05% Ca, 0.85% P, 1.12% K, 0.39% S, and 0.9% starch (DM basis). On a DM basis, the corn silage used was: 37.0% DM, 44.5% NDF 8.6% CP, 2.2% crude fat, 0.28% Ca, 0.23% P, 1.24% K, 0.10% S, and 29.0% starch.

Cattle from the medium and heavy BW blocks were harvested on d 141 and the light block on d 161 at Cargill Meat Solutions (Fort Morgan, CO). Carcass data were collected by Diamond T Livestock Services Inc. (Yuma, CO). Hot carcass weight and liver scores were recorded on day of harvest. After a 48 h chill, LM area, marbling score, and 12th rib fat thickness were recorded. Yield grade was calculated (Boggs and Merkel, 1993) from the following formula: 2.50 + (6.35*fat thickness, cm) + (0.2* 2.5 [KPH]) + (0.0017*HCW, kg) – (2.06*LM area, cm^2). With the use of a common dressing percentage (63%), final BW, ADG, and G:F were calculated. On d 140 and 160, individual live BW were collected and shrunk 4% to calculate dressing percent.

During the study, four steers died on treatment NEX due to bovine respiratory disease (BRD), urinary calculi, or brisket disease (2,1,1), respectively. Bovine respiratory disease was the cause of one dead on both NEXMT and MT treatments. Two steers were removed due to lameness or BRD and one animal died from urinary calculi, all on the CON treatment. Animal performance and carcass characteristics were analyzed as a 2 x 2 factorial using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C) with pen being the experimental unit and animals removed (BRD, urinary calculi, brisket disease, lameness) from analysis. The model included the effects of MT, NEX, and MT x NEX interaction. Block was treated as a random effect. Although there were no significant ($P \leq 0.05$) MT x NEX interactions, the simple effect means are presented and main effects are discussed. Occurrences of liver abscesses were analyzed using the GLIMMIX procedure of SAS.

RESULTS AND DISCUSSION

Feedlot Performance. The interaction of MT x NEX was not significant ($P > 0.05$; Table 2). Cattle fed MT had no effect on DMI ($P = 0.16$). Feeding monensin plus tylosin typically reduces DMI (Potter et al., 1985). Similarly, Meyer et al. (2009) observed a 5.8% decrease in DMI when steers were fed MT over a 115 d finishing period while Stock et al. (1995) observed a 1% reduction in DMI. In the current study, cattle fed MT showed a tendency ($P = 0.07$) for an improvement in ADG with steers being fed MT gaining 2.8% faster than cattle not fed MT and a similar response was observed by Stock et al. (1995). Galyean et al. (1992) evaluated monensin plus tylosin fed to steers consuming a high-concentrate diet and did not observe an improvement in ADG compared to control cattle. The addition of MT improved G:F compared to cattle without MT ($P < 0.01$). A 3.9% improvement in G:F was observed with the use of MT. A greater improvement in G:F was observed by Potter et al. (1985) summarizing data form 14 experiments showing the effects of monensin and tylosin when fed in combination. The 3.9% improvement in G:F in the current study was primarily due to the numerical improvements in ADG for cattle fed MT. To a lesser extent, the numeric (1.5%)

reduction in DMI when MT was fed may have also contributed to this. A trend (P = 0.07) for an increase in final BW was observed for cattle fed MT.

There was no difference (P = 0.58) in DMI between cattle fed NEX and those without NEX. Yang et al. (2010) supplemented increasing amounts (0, 400, 800, or 1600 mg/steer/d) of cinnamaldehyde (CIN) to steers fed an 86% dry-rolled corn diet and observed a tendency for a quadratic effect on DMI, with DMI being least with the addition of CIN at 1600 mg/d and greatest at 400 mg/d. Average daily gain was not different (P = 0.85) for cattle fed NEX compared to cattle without NEX, which is in agreement with previous work with essential oils (Meyer et al., 2009; Yang et al., 2010). The addition of NEX had no effect (P = 0.87) on G:F. Meyer et al. (2009) showed a tendency for an improvement in G:F with the addition of essential oils. Similarly, Benchaar et al. (2006) evaluated the effects of a commercial mixture of essential oils (Vertan®) to steers fed a 75% grass/legume silage diet and observed an improvement in feed efficiency with the addition of an essential oil mixture at 2 g/d. In the present experiment an improvement in final BW was not observed (P = 0.81) due to feeding NEX.

Carcass Characteristics. There were no significant (P > 0.05; Table 2) for a MT x NEX interaction for carcass data. There was a trend (P = 0.07) for an increase in HCW and a significant (P < 0.01) improvement in marbling score for cattle fed MT compared to cattle without MT. This improvement in marbling score does not agree with previous work where marbling score was unchanged (Heinemann et al., 1978) or tended to decrease (Meyer et al., 2009), but in these studies they observed a decrease in DMI which could partially affect marbling score. In the current study, the prevalence of liver abscesses ranged from 13.6 to 29.2% across treatments, which is similar to the observation of Brink et al. (1990). Cattle fed MT (14.6%), reduced ($P < 0.01$) the incidence of liver abscesses by 45.7% compared to cattle without MT (26.9%). The presence of liver abscesses (A) ranged from 6.6 to 11.5% while severe (A+) liver abscesses ranged from 8.1 to 15.1% for cattle fed MT compared to those without MT. A similar reduction in liver abscesses was observed with the use of monensin plus tylosin by Meyer et al. (2009), but Potter et al. (1985) suggested monensin to have no effect on liver abscesses. The reduction of liver abscesses, with the use of tylosin has been well documented (Pendlum et al., 1978; Potter et al., 1985; Vogel and Laudert, 1994). Dressing percent, LM area, 12^{th} rib fat thickness, and calculated yield grade were unaffected ($P \geq 0.19$) in the presence or absence of MT.

Compared to cattle without NEX (18.9%), the addition of NEX (22.6%) had no impact ($P = 0.37$) on the occurrence of liver abscesses. Severe (A+) liver abscesses were similar (11.3 vs. 11.8%) between cattle fed with and without NEX. Research on the effects of essential oils and in liver abscesses is minimal. Meyer et al. (2009) reported no difference in the prevalence of liver abscess with an experimental essential oil mixture containing guaiacol, linalool, and α-pinene, but observed a 39% decrease in liver abscesses using an essential oil mixture of thymol, eugenol, vanillin, guaiacol, and limonene compared to cattle fed no additives. The main effect of NEX had no impact ($P \geq 0.75$) on HCW, dressing percent, marbling score, LM area, 12^{th} rib fat thickness, or calculated yield grade. In agreement, Meyer et al. (2009) observed no differences in carcass characteristics. Yang et al. (2010) supplemented cinnamaldehyde at increasing dosage amounts to steers fed a high-concentrate diet and observed no differences in carcass characteristics. Furthermore, Chaves et al. (2008) supplemented lambs fed with either barley or corn grain based diets with cinnamaldehyde and garlic and observed no effect on carcass characteristics.

IMPLICATIONS

The addition of NEXT ENHANCE at 300 mg/d in finishing diets had little impact on animal performance or carcass characteristics and were comparable to diets without NEXT ENHANCE. Feed efficiency was improved when cattle were fed monensin plus tylosin. Additionally, the prevalence of liver abscesses decreased with the inclusion of monensin plus tylosin in the diet.

LITERATURE CITED

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TABLES

Table 1. Composition of dietary treatments and formulated nutrient composition.

Ingredient	% of diet DM
Dry-rolled corn	53
Wet distillers grains solubles	25
Corn Silage	16
Supplement	6
Analyzed Nutrient Composition	
Crude Protein, %	13.9
Calcium, %	0.52
Phosphorus, %	0.40
Potassium, %	0.92
Crude fat, %	4.84
Neutral Detergent Fiber, %	22.3
Starch, %	42.4

Table 2. Effect of including feed additives on cattle performance and carcass characteristics.

Item	Treatment[1]				SED	*P-value*		
	CON	NEX	MT	NEXMT		NEX[2]	MT[3]	NEX x MT[4]
Performance								
Initial BW, kg	295	295	295	295	0.49	0.44	0.80	0.70
Final BW, kg[5]	556	559	565	564	5.1	0.81	0.07	0.59
DMI, kg /d	10.1	10.2	10.0	10.0	0.1	0.58	0.16	0.46
ADG, kg	1.77	1.79	1.83	1.82	0.03	0.85	0.07	0.61
G:F	0.176	0.176	0.183	0.183	0.003	0.87	<0.01	0.96
Final Live BW, kg	583	584	592	593	4.2	0.80	<0.01	0.89
Carcass Characteristics								
HCW, kg	351	352	356	355	3.2	0.80	0.07	0.59
Dressing, %	62.7	62.8	62.6	62.4	0.01	0.98	0.27	0.53
Marbling[6]	522	530	557	554	11	0.76	<0.01	0.48
LM area, cm^2	78.7	80.0	77.4	78.5	0.9	0.75	0.46	0.15
12^{th} rib fat, cm	1.47	1.52	1.55	1.50	0.04	0.90	0.55	0.17
Calculated YG[7]	3.39	3.48	3.56	3.46	0.08	0.92	0.19	0.10
Liver abscess[8], %	24.7	29.2	13.1	16.2	-	0.37	<0.01	0.97
A, %	9.4	13.5	4.0	9.1	-	0.10	0.08	0.56
A+, %	14.6	15.6	9.1	7.1	-	0.77	0.03	0.59

[1]CON = Control, NEX = NEXT ENHANCE, MT = monensin+tylosin, NEXMT = NEXT ENHANCE + monensin+tylosin.

[2]NEX = *P*-value for the main effect of NEXT ENHANCE inclusion.

[3]MT = *P*-value for the main effect of monensin/tylosin inclusion.

[4]NEX x MT = *P*-value for the NEXT ENHANCE x monensin/tylosin interaction.

[5]Calculated from carcass weight, adjusted to 63% common dressing percent.

[6]Marbling Score: 400 = slight, 500 = small, 600 = modest, etc.

[7]YG = 2.50 + (6.35*fat thickness, cm) + (0.2*KPH,%) + (0.0017*HCW, kg) – (2.06*LM area, cm^2).

[8]Liver score: A = 1 or 2 small abscesses, up to 2 to 4 well organized abcesses; A+ = 1 or more large, active abscesses.