

Management Strategies for Use of High-Alkaloid Grass Seed Straw

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Introduction

The vast majority of U.S. grass seed production occurs in the states of Oregon, Washington, and Idaho. These states produce approximately 90% of all Kentucky bluegrass (*Poa pratensis* L.) grown in the United States, with 70 to 80% grown in northern Idaho and eastern Washington. In addition, Oregon produces approximately 99% of all ryegrass and orchardgrass (*Dactylis glomerata* L.) seed and 64% of all fescue seed harvested in the United States (Oregon Agricultural Statistics Service, 2001-2002). A byproduct of grass seed production is straw. In 1999, approximately 900,000 tons of grass seed straw was available in Oregon (86%), Idaho (6%), and Washington (8%; Fiber Futures, 2003).

While grass seed straw is generally a low-quality forage source (< 6% CP; DM basis), the ruminant animal and its microbial population can utilize it with proper nutritional management. Consequently, grass seed straw can be an economical alternative to traditional sources of low-quality forage (meadow hay, sorghum hay, cornstalks, etc.) used to maintain cowherds in areas of the U.S. and Canada requiring harvested or stockpiled forage for extended periods of time (Bohnert et al., 2003). However, some species of grass seed straw contain alkaloids which can cause animal health, performance, and/or neurological problems. As a result, alkaloid concerns have hampered its use as a forage source for ruminants. In this paper, we discuss concerns and management strategies associated with feeding high-alkaloid grass seed straw to ruminants.

Alkaloid Concerns

The two most common species of grass seed straw that can contain high levels of alkaloids are tall fescue (*Festuca arudinacea*) and perennial ryegrass (*Lolium perenne*). The alkaloid most often associated with tall fescue straw is ergovaline while perennial ryegrass straw may contain ergovaline and lolitrem B (Stamm, 1992). Alkaloids are produced by endophytic fungi that exist in a symbiotic relationship with their plant host (Aldrich-Markham and Pirelli, 1995; Hannaway et al., 1997; Hannaway et al., 1999). The causative fungi thought to produce ergovaline and lolitrem B are *Neotyphodium coenophialum* and *Neotyphodium lolli*, respectively.

Tall fescue

Consumption of alkaloids in tall fescue have caused fescue foot, summer syndrome or slump, fat necrosis, decreased serum prolactin (a hormone necessary for mammary development and milk production),agalactia (decreased milk production), and reproductive problems in ruminants consuming tall fescue (Hemken et al., 1984; Stuedemann and Hoveland, 1988; Hemken and Bush, 1989). Hoveland (1993) estimated the annual economic losses to the U.S. Beef industry, attributable to the aforementioned conditions, to be more than \$600 million.

Fescue foot results in gangrene of the extremities, particularly tails, hooves, and ears, and occurs during cold temperatures, particularly in the late fall and winter. Fescue foot begins with a reduction in animal performance (Hemken and Bush, 1989), with animals having a rough hair coat, arched back, and soreness in one or both rear limbs (Hemken et al., 1984). Hyperemia and swelling of the coronary band occurs and, if the animals continue consuming infected tall fescue, eventually the hooves may be sloughed (Hemken and Bush, 1989).

Symptoms of summer syndrome include reduced performance, agalactia, decreased feed intake, rough hair coat, elevated body temperature, inability to dissipate body heat, increased respiration rate, decreased serum prolactin, excessive salivation, and reduced reproductive performance (increased time to conception, reduced conception and calving rates, and increased embryonic mortality compared with animals not consuming high-alkaloid tall fescue; Bond et al., 1982; Hemken et al., 1984; Hoveland, 1993). This condition normally occurs in the summer months when environmental temperatures are greater than 23° C. Another symptom, fat necrosis, occurs when blood flow to the body core decreases causing the abdominal fat to harden and die resulting in necrotic lesions that can cause constriction of intestines, reproductive problems, and kidney failure (Stuedeman et al., 1975).

Perennial ryegrass

Consumption of alkaloids in perennial ryegrass can cause health disorders normally associated with tall fescue, along with a neurological disorder associated with consumption of lolitrem B called “perennial ryegrass staggers”. Stamm (1992) reported the average ergovaline concentration of 136 samples of perennial ryegrass and 122 samples of tall fescue straw was 214 ppb and 86 ppb, respectively. In addition, 14% of the tall fescue fields sampled had ergovaline levels greater than 200 ppb while 42% of perennial ryegrass fields contained ergovaline levels greater than 200 ppb. Furthermore, Hovermale and Craig (2001) reported that there is a strong relationship ($r^2 = 0.73$) between lolitrem B and ergovaline concentration in perennial ryegrass.

Perennial ryegrass staggers normally manifests itself in ruminants after consuming lolitrem B infected perennial ryegrass for 7 to 14 days. Clinical symptoms include incoordination, staggering, tremors, head shaking, and collapse (Aldrich-Markham and Pirelli, 1995; Cheeke, 1995). While death can result from perennial ryegrass staggers, it is normally associated with misadventure (stumbling off a cliff, entering a pond to cool off and drowning, etc.; Cheek, 1998). Animals demonstrating clinical symptoms should be removed from the causative feed source, whereby symptoms normally subside in 2 to 14 days. Economic losses associated with staggers (estimated as \$100 million annually in New Zealand; AgResearch, 2005) are primarily because of decreased daily weight gains and depression of hormonal levels associated with reproduction and lactation (Prestidge, 1993).

Ergovaline and Lolitrem B Threshold Levels

Concentration Thresholds

The current threshold concentrations for ergovaline and lolitrem B, above which clinical signs of toxicosis are typically observed in sheep, cattle, and horses, are presented in Table 1. As

noted previously, perennial ryegrass can have significant quantities of both lolitrem B and ergovaline. After analyzing over 450 samples of perennial ryegrass straw from Oregon and regressing lolitrem B concentration on ergovaline level, Hovermale and Craig (2001) suggest that straw containing 2000 ppb lolitrem B can be expected to have approximately 175 ppb ergovaline, which indicates the first symptoms of toxicosis to be observed with high-alkaloid perennial ryegrass straw will normally be staggers. However, some straws may not fit the data of Hovermale and Craig (2001); therefore, it is prudent to test perennial ryegrass for both lolitrem B and ergovaline.

Intake Thresholds

The cause of perennial ryegrass staggers and fescue toxicosis is not directly caused by the concentration of alkaloids in the straw/grass. The alkaloid intake causes the problem. In other words, think of an alkaloid intake threshold in the same way as a nutrient requirement. A certain quantity of an alkaloid, not a concentration, is needed to cause toxicosis. Nevertheless, alkaloid thresholds are almost exclusively reported as concentrations. Therefore, we compiled data from studies known to us to report alkaloid intake (or alkaloid concentration and forage intake values), animal body weight, and effects of alkaloid consumption (Table 2). The alkaloid intake data is reported on a metabolic body weight ($BW^{0.75}$) basis to allow for comparison across various species and weights. Based on this data, it appears that the ergovaline and lolitrem B intake thresholds (above which toxicosis symptoms/indices can be expected) for cattle are approximately 0.035 mg/kg $BW^{0.75}$ and 0.010 mg/kg $BW^{0.75}$, respectively. The ergovaline intake threshold for sheep appears to be approximately 0.045 mg/kg $BW^{0.75}$. We are aware of no data available that allows for calculation of alkaloid intake based on metabolic BW for horses or lolitrem B intake in sheep. However, because the lolitrem B concentration threshold is similar for cattle and sheep, we can assume that the intake threshold, on a metabolic BW basis, would be similar as well (0.010 mg/kg $BW^{0.75}$). This assumption is strengthened by the fact that our estimated difference in ergovaline intake threshold between sheep and cattle (28% greater for sheep) is comparable to the difference in concentration threshold (25% greater for sheep).

Climate

Climate, specifically environmental temperature, has little influence on threshold level for lolitrem B; however, cold temperatures can lower the threshold for ergovaline. Consequently, the quantity of ergovaline considered toxic in the Pacific Northwest is closely related to environmental temperatures. This is especially important because most, if not all, of grass seed straw feeding occurs during the winter when temperatures can routinely be below -15° C in many areas of the intermountain west. The frigid temperature and decreased blood flow to the periphery, due to alkaloid-induced vasoconstriction (Abney et al., 1993; Klotz et al., 2006), often results in the freezing of feet and severe cases of fescue foot. Such an occurrence took place during the winter of 2001-2002 in Eastern Oregon. Three beef producers who were feeding tall fescue straw (containing approximately 400 ppb ergovaline) to spring-calving beef cows had to destroy approximately 600 head of mature cows when cold temperatures occurred (two weeks below 0° C; D. Bohnert, Eastern Oregon Agricultural Research Center files). Decreased peripheral blood flow to the extremities caused the affected cows to suffer severe

frostbite resulting in the sloughing of their hooves (Figure 1). Total long-term losses from the three ranches approached an estimated 1.3 million dollars.

The majority of grass seed straw is provided to gestating cows from November to February; therefore, some of the symptoms of fescue toxicosis are not observed when high-ergovaline straw is fed. Specifically, reproductive problems, elevated temperature and associated heat stress, excessive salivation, decreased intake, and fat necrosis. The reason for the lack of these symptoms with winter-feeding of high-ergovaline straw is primarily because they normally occur when the environmental temperature is greater than 23° C, which rarely occurs during the winter in the intermountain west. Therefore, the main concerns with fescue toxicosis resulting from straw feeding are fescue foot and decreased serum prolactin and milk production.

Alkaloid Detection

Testing & Sampling

The alkaloid content of grass seed straw must be determined with laboratory testing. This is important if the species of grass seed straw to be used has the potential to contain high levels of ergovaline and/or lolitrem B (normally tall fescue and perennial ryegrass). If perennial ryegrass straw is tested, it should be tested for ergovaline as well as lolitrem B because of the potential to contain both alkaloids.

Oregon State University can test for alkaloids. The contact information for the lab is:
139 Oak Creek Building
Endophyte Service Laboratory
College of Agricultural Sciences
Oregon State University
Corvallis, OR 97331
Phone: 541-737-2872

A set of sample collection instructions, along with pricing information, can be found at the following web site: http://cropandsoil.oregonstate.edu/seed-ext/Pub/endophyte_sampling_of_straw.pdf.

The alkaloid content of a stack, or lot, of straw can vary tremendously. Therefore, it is critical to get a representative sample of the straw to be tested. A very thorough and complete set of “Recommended Principles for Proper Hay Sampling” has been put together by D. H. Putnam at UC-Davis (http://alfalfa.ucdavis.edu/+producing/forage_quality/hay_sampling/HAYSAMPLINGSTEPS.htm). Briefly, the following steps are recommended: 1) identify a single lot/stack of hay or straw; 2) use a proper sampling, or coring, device; 3) sample at random; 4) take enough cores to make up a representative sample; 5) use a proper sampling technique; and 6) handle and prepare the sample correctly. A more detailed description of the procedures can be found on the referenced web site.

Management Strategies

Grass seed straws that contain alkaloid levels above the recommended threshold concentrations can be effectively used as forage resources. However, this will require increased nutritional management and diligent observation of livestock consuming the residue.

Blending

Currently, the most common and effective means of feeding high-alkaloid grass seed straw is to blend it with non- or low-alkaloid forage. The “rule of thumb” has been to use a 50:50 mix of high and non- alkaloid forage. This will normally be sufficient to eliminate, or greatly decrease, the chance of developing symptoms of alkaloid toxicity.

Two studies have evaluated blending of high and low-alkaloid straws to reduce the potential for toxicity (Stamm et al., 1994; Fisher et al., 2004). Stamm et al. (1994) used a high-alkaloid and a low-alkaloid tall fescue straw to obtain ergovaline concentrations of 0, 158, 317, and 475 ppb in the forage offered to steers and reported no health problems, negative affects on dry matter intake or nutrient digestibility, or reductions in animal performance. Also, Fisher et al. (2004) mixed two perennial ryegrass straws to get increasing levels of lolitrem B to ruminants and noted no adverse effects on nutrient intake and digestibility, physiological response variables, animal performance, or milk production when the “blended” straws had an average lolitrem B level of less than 1550 ppb. However, Fisher et al. (2004) did report that 13 of 24 (54%) cows consuming the high-alkaloid perennial ryegrass straw, containing 2017 ppb lolitrem B, exhibited clinical symptoms of perennial ryegrass staggers.

Another common practice used to dilute high-alkaloid straw is to feed alfalfa hay as a protein supplement. Grass seed straw typically contains less than 6% CP (DM basis) and normally requires some form of protein supplementation to meet the animal’s requirements (Bohnert et al., 2003). The quantity of alfalfa needed to supplement a grass seed straw diet depends on the crude protein content of the straw and alfalfa and physiological status of the animal. Also, this type of feeding management requires an accurate knowledge of the alkaloid content of the straw, the alkaloid intake threshold, and the daily quantity of straw provided.

Alternate Day(s) Feeding

A modified type of mixing or blending practice is to provide the high-alkaloid straw on a separate day from the low-alkaloid or alkaloid-free forage. The simplest example would be to provide high-alkaloid straw every-other-day with hay or low-alkaloid straw provided on the alternate days. This serves the same purpose as diluting the high-alkaloid straw by 50%. In addition to reducing the overall alkaloid intake, feeding straw on alternate days has the following additional benefits compared with a “hay mix” every day: 1) less work, and potential human error, feeding one forage source per day compared with two; 2) more consistent intake of both forage sources due to minimization of sorting and the “boss” effect caused by dominant animals in the herd or flock; and 3) better control over alkaloid intake, especially if alkaloid concentration and intake thresholds are known. For instance, it may be possible to provide the

high-alkaloid straw two out of three days and still maintain alkaloid intake below threshold levels.

Feed Additives/Pharmacological Products

There are a number of products that claim to reduce the negative effects of fescue toxicosis in ruminants. Some of the more common are MTB-100[®] (Formerly marketed as FEB-200[®]; Alltech, Inc., Nicholasville, KY), Fescue Endo-Fighter[™] (ADM Alliance Nutrition, Quincy, IL), and Tasco[™] (Acadian Seaplants Ltd., Dartmouth, Nova Scotia, Canada). We are unaware of any products currently available that claim to minimize the toxic effects of lolitrem B (perennial ryegrass staggers).

Our lab has recently completed a series of studies evaluating the ability of MTB-100[®], a modified glucomannan, to reduce the symptoms of fescue toxicosis (Merrill et al., unpublished data). The preliminary results are favorable. Briefly, the data suggests that the product increases serum prolactin in cattle consuming high-alkaloid tall fescue straw (Figure 2). Also, cows receiving MTB-100[®] during the last third of gestation had greater milk production 60 days postpartum than cows not receiving the product during the last third of gestation (Figure 3). In addition, data from the University of Kentucky suggests that the product can increase weight gain of cows and calves grazing endophyte-infected tall fescue (Ely et al., 2006).

Fescue Endo-Fighter is a patent-pending product sold exclusively by ADM Alliance Nutrition which is “specifically formulated for cattle grazing fescue pasture or consuming fescue hay that is infected with the fescue toxin”. The product is delivered within the company’s mineral line (e.g. MasterGain Fescue Range Minerals with Endo-Fighter). The claims of the product include increased cow and calf gains, increased grazing time, and improved hair coat by cattle grazing endophyte-infected fescue pastures. It should be noted that minerals containing this product should not be offered to sheep.

Tasco-Forage is a water-soluble extract of the brown seaweed *Ascophyllum nodosum* harvested off the coast of Nova Scotia and prepared by a proprietary process. Benefits of using the product have included improved hair coat and immune function in cattle consuming infected tall fescue, increased antioxidant activity in sheep and cattle, increased marbling and USDA quality grade, and increased shelf-life of meat from cattle grazing fescue pastures (Allen et al., 2001).

The data available for each of the aforementioned products suggests they are effective in reducing some of the symptoms of fescue toxicosis. However, they should not be considered a “magic bullet” to solve all of the problems associated with fescue toxicosis. Instead, they should be considered as tools that can be used in developing nutritional management plans to help producers use a forage resource in a safe and effective manner.

Conclusion

Given its availability and potential to lower feed costs, grass seed straw should be considered when designing winter-feeding programs. However, grass seed straw should be

tested to determine its nutritional quality. Also, if the straw is from a grass species that may contain alkaloids, it is strongly recommended that the producer have the appropriate test(s) conducted to determine the alkaloid concentration(s). Listed below are a series of recommendations that a ruminant livestock producer should consider before feeding grass seed straw.

- 1) Know the species of grass seed straw (tall fescue, perennial ryegrass, bluegrass, etc.) and if it can potentially contain toxic levels of alkaloids.
- 2) If the grass seed straw has the potential to contain elevated levels of alkaloids, obtain a representative sample and have it tested for ergovaline (tall fescue and perennial ryegrass varieties) and/or lolitrem B (perennial ryegrass varieties).
- 3) Be aware of the concentration and intake thresholds for ergovaline and/or lolitrem B.
- 4) If the grass seed straw is considered acceptable, develop a nutritional management plan for its safe and effective use (contact your county agent, extension specialist, or nutritionist for assistance).

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Table 1. Estimated alkaloid threshold levels (parts per billion; ppb) for fescue toxicosis and perennial ryegrass staggers in cattle and sheep (adapted from Hovermale and Craig., 2001).

Species	*Ergovaline (ppb)	Lolitrem B (ppb)
Cattle	400-750	1800-2000
Sheep	500-800	1800-2000
Horses	300-500	Not determined

*Threshold level is environmentally dependent and decreases in cold weather.

1 Table 2. Review of alkaloid intake data, reported on a metabolic body weight ($BW^{0.75}$) basis, and associated effects.

Study	Species	Alkaloid intakes, mg/kg $BW^{0.75}$	Effect
Ergovaline Intakes			
Stamm et al., 1994	Steers, Exp. 1	0; 0.011; 0.021; 0.036	None
	Steers, Exp. 2	0; 0.012; 0.024; 0.035	None
Aldrich et al., 1993a	Heifers, Exp. 1	0; 0.05	Decreased prolactin (PRL)
	Cows, Exp. 2	0.021; 0.028; 0.037	Decreased intake, digestibility, & skin vaporization (SV)
Aldrich et al., 1993b	Lambs, Exp. 1	0; 0.053; 0.073	Decreased intake & digestibility; Increased temp.; altered ruminal fluid dynamics
	Lambs, Exp. 2	0; 0.089; 0.118	Decreased intake, SV, & PRL; Increased temp.
Hannah et al., 1990	Lambs, Exp. 1	0; 0.10; 0.20	Decreased digestibility & altered ruminal fluid dynamics
Emile et al., 2000	Heifers, Exp. 1	0; 0.035	Decreased ADG & PRL
	Lambs, Exp. 2	0; 0.058	Decreased ADG & PRL
Peters et al., 1992	Cows	0.011; 0.028; 0.040; 0.057	Decreased intake, calf ADG, & calf milk intake; Increased cow wt. loss & respiratory stress
Rhodes et al., 1991	Lambs, Exp. 1	0; 0.057	Decreased intake
	Steers, Exp. 2	0; 0.040	Decreased peripheral blood flow, Increased temp.
Merrill et al. (Unpublished)	Steers, Exp. 1	0.038	Decreased PRL stores
	Cows, Exp. 2	0.015; 0.042; 0.041; 0.045; 0.039	Decreased PRL & milk production; 1 cow out of 60 developed fescue foot (0.045 intake)
Lolitrem B Intakes			
Fisher et al., 2004	Steers, Exp. 1	0.004; 0.047; 0.090; 0.129	None
	Cows, Exp. 2	0.026; 0.068; 0.133	54% (13 of 24) of 0.133 TRT developed staggers; No incidences on other levels



Figure 1. A cow that has sloughed her rear hooves after consuming endophyte infected tall fescue straw during a period of cold weather in Eastern Oregon.

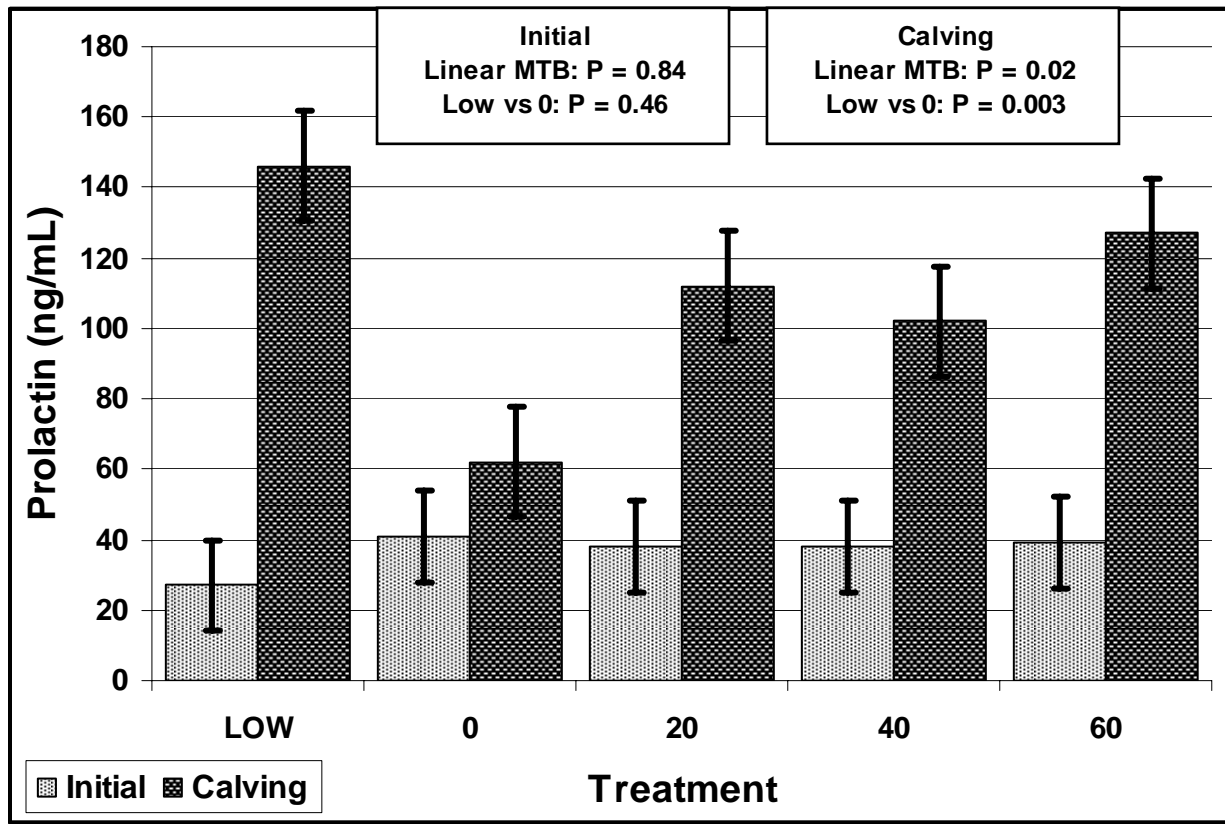


Figure 2. Serum prolactin levels in mature cows. Initial values are at study initiation and Calving values are within 24 hours post-calving (cows had received treatments for 75 ± 2 days). Treatments applied during the last third of gestation were: Low = 147 ppb ergovaline tall fescue straw; 0 = 449 ppb ergovaline tall fescue straw + 0 g/d of a modified glucomannan (MTB-100[®]; Alltech, Inc., Nicholasville, KY); 20 = 449 ppb ergovaline straw + 20 g/d of MTB-100[®]; 40 = 449 ppb ergovaline tall fescue straw + 40 g/d MTB-100[®]; 60 = 449 ppb ergovaline tall fescue straw + MTB-100[®]. All cows received 1 kg/d SBM during the straw feeding period. Merrill et al. (unpublished data).

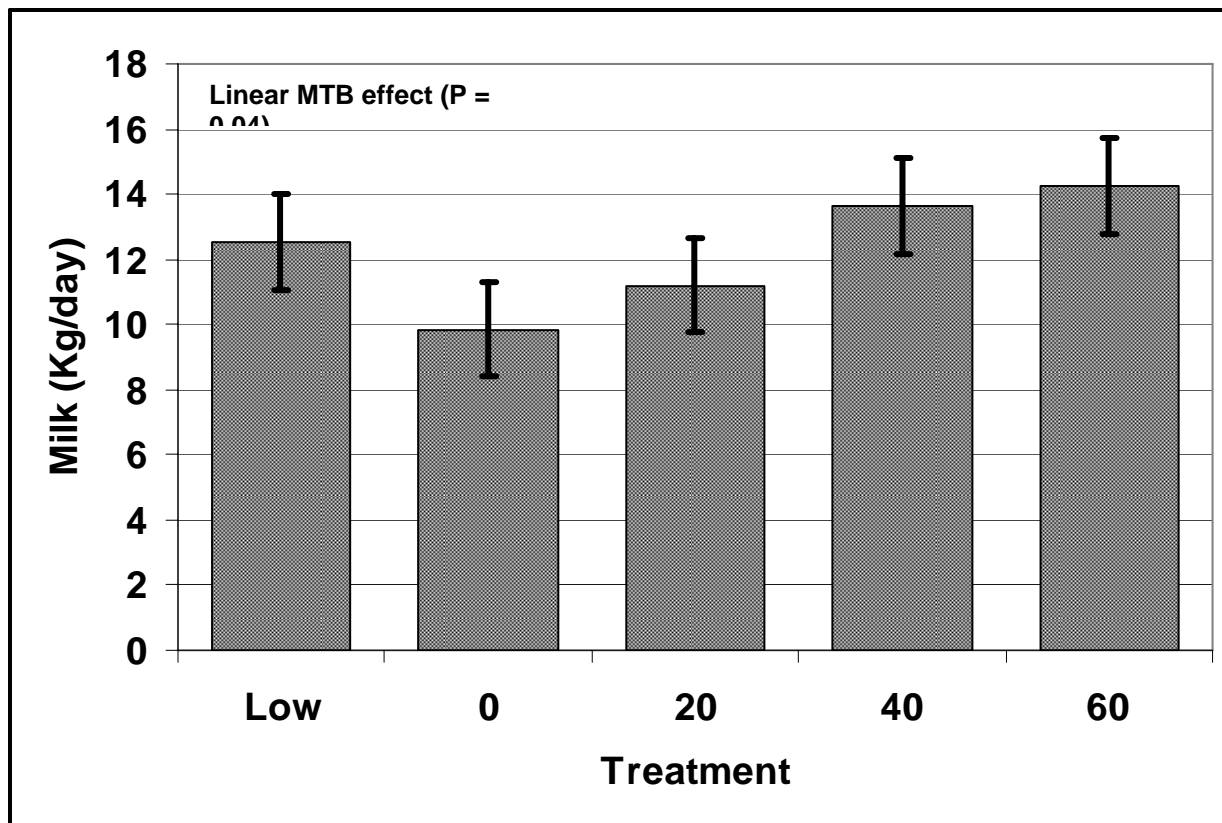


Figure 3. Milk production of mature beef cows 60 ± 1 days post-calving. Treatments applied during the last third of gestation were: Low = 147 ppb ergovaline tall fescue straw; 0 = 449 ppb ergovaline tall fescue straw + 0 g/d of a modified glucomannan (MTB-100[®]; Alltech, Inc., Nicholasville, KY); 20 = 449 ppb ergovaline straw + 20 g/d of MTB-100[®]; 40 = 449 ppb ergovaline tall fescue straw + 40 g/d MTB-100[®]; 60 = 449 ppb ergovaline tall fescue straw + MTB-100[®]. All cows received 1 kg/d SBM during the straw feeding period. After calving, cows were managed as a single herd and received native meadow hay until spring-turnout. Merrill et al. (unpublished data).