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Effect of pelleting on efficacy of sericea lespedeza hay as a natural dewormer in goats

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Abstract

Resistance of gastrointestinal nematodes (GIN) to anthelmintic treatment has increased pressure to find alternative, non-chemical control methods. Feeding hay of the high condensed tannin (CT) forage sericea lespedeza [SL; *Lespedeza cuneata* (Dum-Cours.) G. Don.] to sheep and goats has reduced GIN fecal egg count (FEC) and worm numbers in the abomasum and small intestines. This effect has been reported with both unground (long) and ground hay. Pelleting of ground hay increases ease of storage, transport, and feeding, but heating during the pelleting process could reduce biological activity of CT. Eighteen naturally GIN-infected 5–6-month-old Kiko-Spanish cross bucks were fed pelleted and ground SL hay and ground bermudagrass [BG; *Cynodon dactyon* (L.) Pers.] hay diets ($n = 6$ per treatment) in a confinement trial. The bucks were fed the ground BG hay (75% of daily intake) plus a pelleted 16% CP commercial goat chow (25% of daily intake) for 3 weeks, after which they were assigned to treatment groups based upon FEC, 12 animals were switched to ground and pelleted SL hay plus goat chow for 4 weeks, and then all animals were fed the BG ration for one additional week. Throughout the trial, feces and blood were collected from individual animals weekly to determine FEC and blood packed cell volume (PCV), respectively. All goats were slaughtered at the end of the trial, with adult worms in the abomasum and small intestines recovered, counted, and identified to species. Both forms of SL hay reduced ($P < 0.05$) FEC in goats relative to BG hay-fed animals, with a greater reduction in goats fed the SL pellets. There was no effect on PCV until the final sampling date, when the SL pellet-fed goats' PCV increased ($P < 0.05$) compared with the other treatments. Feeding pelleted SL reduced ($P < 0.05$) abomasal worms, primarily *Haemonchus contortus*, relative to the BG hay-fed goats. Worm numbers in the goats fed ground SL hay were intermediate. Pelleting SL hay enhanced its efficacy against parasitic nematodes and may facilitate the broader use of this forage in small ruminant GIN control programs.

Keywords: Sericea lespedeza; Hay; Pellets; Goats; Condensed tannins; Gastrointestinal nematodes

1. Introduction

Infection with gastrointestinal nematodes (GIN), particularly *Haemonchus contortus* (Barber pole worm) continues to be the primary constraint to profitable goat production in the USA. Resistance to treatment with

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chemical anthelmintics is increasing world-wide, and there have been a number of recent reports from the southern USA documenting increased prevalence of GIN resistance to drugs from all three primary anthelmintic families (Zajac and Gipson, 2000; Terrill et al., 2001; Mortensen et al., 2003). Mortensen et al. (2003) reported resistance to albendazole on 14 out of 15 goat farms in Georgia, and to ivermectin, levamisole, and moxidectin on 17, 6, and 1 of 18 farms, respectively. Complete anthelmintic failure was recently confirmed in a herd in Arkansas (Kaplan et al., 2005). This emerging challenge has greatly increased pressure to find alternative, non-chemical small ruminant GIN control methods as a replacement/supplement to the exclusive use of chemical anthelmintics.

One promising natural control method is feeding fresh or dried forages containing relatively high levels of condensed tannins (CT) to parasitized sheep and goats. There have been a number of reports documenting reduced GIN infection levels in sheep and goats grazing CT-containing forages, including sulla (*Hedysarum coronarium* L.), birdsfoot trefoil (*Lotus corniculatus* L.), big trefoil (*Lotus uliginosis* Schkuhr), and sericea lespedeza [SL; *Lespedeza cuneata* (Dum-Cours.) G. Don.] (Niezen et al., 1995, 2002; Min and Hart, 2003; Min et al., 2004). Because of the seasonal limitations and land requirements for grazing CT forages, several investigators have tested the anthelmintic efficacy of CT forages in dried form (Paolini et al., 2003; Kahiya et al., 2003). Promising results from feeding unground (long) and ground hay of sericea lespedeza to GIN-infected sheep and goats have recently been reported (Shaik et al., 2004, 2006; Dykes et al., 2006; Lange et al., 2006). Shaik and colleagues (Shaik et al., 2006) observed an 80% reduction in FEC in goats fed SL hay compared with a bermudagrass [BG; *Cynodon dactyon* (L.) Pers.] hay diet. The SL-fed goats also had less development of *H. contortus* larvae in fecal cultures, and approximately 70% fewer adult *H. contortus* in their abomasum.

Some of the challenges of feeding hay to livestock in long form or as ground material are feed wastage, difficulty of mixing with other ration ingredients, and cost and difficulty of transport and storage. Pelleting reduces wastage and improves ease of transporting and storing feed, but requires some heating of the forage material during the pelleting process. Drying and heating of CT forage has been reported to shift CT from extractable to bound forms (Terrill et al., 1990, 1992). Although sun-drying and grinding does not appear to reduce the anthelmintic efficacy of SL against small ruminant GIN (Shaik et al., 2004; Dykes et al., 2006), it is not known if the heating inherent in the pelleting process will reduce the anthelmintic properties of this plant.

The objective of this study is to test the anthelmintic efficacy of pelleted and non-pelleted SL hay against GIN of growing goats.

2. Materials and methods

2.1. Experimental design and protocol

A 5-week confinement feeding trial with eighteen 5–6-month-old intact male Kiko-Spanish cross goat kids (40.6 ± 8.7 kg) was completed at the Fort Valley State University Agricultural Research Station, Fort Valley, Georgia, USA. Prior to the start of the trial, the bucks were grazed on infected pasture for 8 weeks to allow development of a natural GIN infection.

2.2. Experimental diets

The goats were moved to a barn into pens with concrete flooring on June 21, 2006, and fed a combination of ground BG hay (75% of daily intake) and a 16% crude protein (CP) pelleted commercial goat chow [Meat Goat 16 (Med.), Purina Mills; St. Louis, Missouri; 25% of daily intake] for a 3-week adjustment period. After the adjustment period, the goats were stratified by FEC and randomly assigned to three dietary treatments ($n = 6$ per treatment) consisting of 75% hay and 25% commercial goat chow. The hay treatments were ground BG, ground SL, and pelleted SL (Both SL treatments were from the same hay cutting). The SL hay was pelleted at Bluebonnet Feeds, Brownwood, TX, using only water as the binding agent. Temperature of the feed was monitored during the pelleting process and did not rise above approximately 70 °C. The goats were initially fed the treatment diets at 3.5% of BW and then increased as needed in 10% increments to allow approximately 10% uneaten feed daily. Feed allowance was adjusted upward twice for both the ground SL and BG diets, and three times for the pelleted SL diet due to higher consumption of this ration. The goats were fed the experimental rations for 4 weeks, after which all animals were switched back to the BG hay ration for one additional week. The bucks were given access to water *ad libitum* throughout the trial.

2.3. Analysis of hay samples

The hays were analyzed for CP, neutral detergent fiber (NDF), acid detergent fiber (ADF), and total

Table 1
Constituents of treatment forages offered to parasitized goats at 75% of intake

Treatment hay	Form	Constituents[a] (%)							
		Extr. CT	PB CT	FB CT	Tot CT	CP	NDF	ADF	TDN
Sericea lespedeza	Ground	1.35	4.68	0.44	6.47	11.4	46.4	36.0	55.0
	Pelleted	0.56	5.38	0.42	6.36	NA	NA	NA	NA
Bermudagrass	Ground	NA	NA	NA	NA	10.5	71.8	29.9	60.8

[a] CT, condensed tannins; Extr., extractible; PB, protein bound; FB, fiber bound; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; TDN, total digestible nutrients; NA, not analyzed.

digestible nutrients (TDN) at the University of Arkansas Agricultural Diagnostic Service Laboratory, Fayetteville, AR, and for extractable, protein-bound, and fiber-bound CT content at the Texas Agricultural Experiment Station in Stephenville, TX (Table 1). The CT analyses were completed using the procedure of Terrill et al. (1992) with purified SL tannin as the standard.

2.4. Sampling procedures and analysis

Throughout the trial, fecal and blood samples were collected weekly from individual animals for determination of FEC and packed cell volume (PCV), respectively. Feces were collected rectally, with GIN eggs counted using a modified McMaster procedure (Whitlock, 1948). Data were expressed as eggs per gram (EPG) of feces. Blood samples were taken by jugular venipuncture into EDTA-vacutainer tubes, with PCV determined using a micro-haematocrit centrifuge and reader. Fecal cultures were prepared from samples recovered when the animals were slaughtered at the end of the trial ($n = 6$) to allow counting and identification of nematode larvae to species (*H. contortus*/non-*H. contortus*). The cultures were made as described by Terrill et al. (2004) with slight modifications. To create the Baermann apparatus for larval recovery, deionized water was added directly to the mini-culture chamber to cover the feces. After recovery of the larvae, excess water was removed in sequential settling steps (Terrill et al., 2004) to a final volume of 2.5 mL, with 0.5 mL of 10% formalin added as a preservative. The larvae in two 50 μL aliquots were stained with iodine, counted, and identified to species using a microscope. Percentage GIN larval development was calculated by the following formula:

$$\text{Percentage larval development} = \frac{\text{number of larvae/g feces}}{\text{eggs/g feces}} \times 100.$$

2.5. Recovery and counting of adult nematodes

At the end of the trial, the goats were slaughtered at the USDA-approved abattoir at the FVSU Agricultural Research Station, and adult worms recovered from the abomasum and small intestine, counted, and identified to species and sex as described by Shaik et al. (2006).

2.6. Statistical analysis

The FEC and PCV data were analyzed as a randomized block design using repeated measures analysis with treatment and time in the model (SAS, 1992). Adult worm data and fecal culture data (percentage larval recovery, percentage *H. contortus*) were analyzed using GLM procedure in SAS (1992) with treatment as an independent variable.

3. Results

3.1. Hay analysis

The total CT concentrations in the ground and pelleted SL hay were similar (approximately 6.5%), but the pelleting process resulted in a shift from extractable to protein-bound CT (Table 1). The CP levels of the BG and SL hays were similar (10.5 and 11.4% CP on a dry matter basis, respectively); NDF and TDN were higher in the BG hay, and ADF content was higher in the SL hay.

3.2. Fecal egg counts

The treatment and treatment × time effects were significant ($P < 0.05$) for FEC data. Goats fed both SL hay diets had lower ($P < 0.05$) FEC than the control animals (BG hay diet) 1 week after the treatment diets were started and maintained these differences during the 4-week SL feeding period (Fig. 1). The highest reduction (70%) in FEC was observed with the goats fed the SL pellets, and this reduction level relative to the

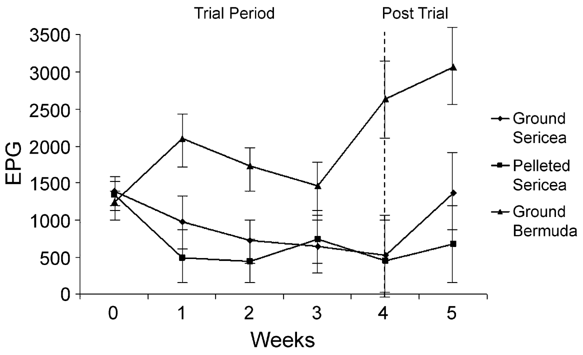

Fig. 1. The effect of feeding ground or pelleted sericea lespedeza (SL) or ground bermudagrass (BG) hay on eggs per gram (EPG ± S.E.M.) of feces from parasitized goats.

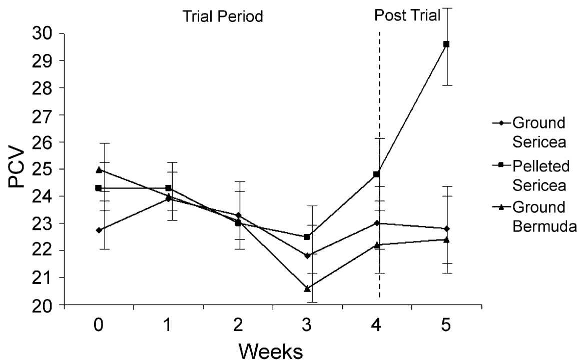

Fig. 2. The effect of feeding ground or pelleted sericea lespedeza (SL) or ground bermudagrass (BG) hay on blood packed cell volume (PCV ± S.E.M.) of parasitized goats.

control animals was maintained even after switching back to the BG hay diet for a week (post-trial period). The reduction level in FEC was lower for the ground SL hay animals (54%) relative to controls, but these differences were also maintained a week after switching back to the BG diet (Fig. 1).

3.3. Blood packed cell volume

There was no overall treatment effect on PCV of the goats, but time and time × treatment were significant ($P < 0.05$). The diets had no effect on blood PCV during the trial period, but there was a significant effect during the post-trial period, when the SL pellet-fed animals were higher ($P < 0.05$) than either of the groups fed ground hay (Fig. 2).

3.4. Percentage larval development in fecal cultures

Larval development from GIN eggs in fecal cultures was similar between all three treatment groups at the end of the trial, but the number of *H. contortus* larvae/g feces and percentage *H. contortus* in the recovered larvae were lower ($P < 0.05$) in the SL pellet goats than in the BG hay animals (Table 2). These values were intermediate for the ground SL goats.

3.5. Adult nematodes

The total number of *H. contortus* adults in the abomasum was lower ($P < 0.05$) in the goats given the SL pellet diet compared with the ground BG hay, with a reduction of approximately 75% (Table 3). The *H. contortus* numbers were intermediate for the ground SL hay animals, approximately 38% lower than the control animals. The dietary treatments had no effect on number of *Ostertagia circumcincta* adults in the abomasum. However, *H. contortus* was the predominant abomasal worm for all treatments. The only small intestinal nematode identified was *Trichostrongylus colubriformis* for all the goats. There was a trend ($P < 0.10$) for lower numbers of *T. colubriformis* for the goats fed SL pellets compared with SL in ground form, but neither of the SL groups was significantly lower in small intestinal worm numbers than the BG group. The goats given the SL pellet diet also tended to be lower ($P < 0.11$) in total worms than goats given either type of ground hay. The treatment diets had no consistent effect on the ratio of male to female nematodes of each species identified.

4. Discussion

Feeding of pelleted SL hay was effective in reducing GIN infection in goats. This confirms previous reports

Table 2
Effect of feeding sericea lespedeza (SL) or bermudagrass (BG) hay and a small amount of concentrates to goats on development of gastrointestinal nematode larvae in fecal cultures

Item	Diet			S.E.M.
	SL ground	SL pellet	BG ground	
H. contortus larvae/g feces	532^{ab}	102^{a}	1882^{b}	384
H. contortus larvae in cultures (%)	52.2^{ab}	25.0^{a}	83.4^{b}	8.4
Larval development in fecal cultures (%)	75.0^{a}	69.6^{a}	56.7^{a}	19.6

Row means with unlike superscripts (a and b) differ significantly ($P < 0.05$).

on the anthelmintic efficacy of this forage as long hay and in ground form (Shaik et al., 2004, 2006; Dykes et al., 2006; Lange et al., 2006). The reduction in FEC relative to control was 77 and 54% for goats fed the pelleted and ground SL rations, respectively. These differences were consistent throughout the trial, even after a week back on the ground bermudagrass diet (78 and 55% reduction in FEC relative to control for pelleted and ground SL, respectively). The FEC reduction level for both ground and pelleted SL hay was comparable to previous reports on parasitized goats fed long SL hay (Shaik et al., 2006; 80% FEC reduction) or ground form (Dykes et al., 2006; 70–90% reduction), and sheep fed ground SL hay (Lange et al., 2006; 80% reduction).

Blood PCV was not affected by the treatment diets until the final sampling, taken at slaughter, when there was a rapid increase in PCV of the SL pellet-fed goats. This supports the worm count and fecal culture data for the goats given the SL pellets, which indicated a reduction in viability of *H. contortus* adults and larvae, respectively. As the primary blood-feeding GIN in tropical and subtropical regions throughout the world, *H. contortus* is the most pathogenic parasite in small ruminants. Any reduction in *H. contortus* numbers in the abomasum should eventually lead to improved anemia scores in goats. Previous studies have reported improvement in anemia level of parasitized goats fed SL hay, but the effect is not as rapid as FEC reduction (Shaik et al., 2006; Dykes et al., 2006).

Lange et al. (2006) reported an increase in FEC in sheep fed SL hay after returning to a BG diet and concluded that the major direct effect of SL hay on GIN is reduced fecundity (egg-laying ability). Because of reduced worm numbers in the abomasum and small intestine of goats fed SL hay, Shaik et al. (2006) concluded that killing the adult worms was the primary direct effect of this forage. The current data suggest that both effects may be occurring, perhaps due to a threshold level of CT intake. After a week off of the SL diets, FEC of the goats fed the ground form increased compared to the animals previously fed the SL pellets. Voluntary consumption of the SL pellet diet was higher than for the goats given either type of ground hay, so the pellet-fed goats likely consumed a greater total amount of CT. This threshold effect may seem counter-intuitive because of the shift to a greater percentage of protein-bound CT in the pelleted SL. Previous work with this forage showed that drying the forage reduced CT extractability and increased intake of sheep (Terrill et al., 1989). However, just as sun-drying and grinding the forage does not appear to reduce its anthelmintic effectiveness compared with grazed material (Shaik et al., 2006; Dykes et al., 2006; Min et al., 2004), neither does pelleting it. In fact, pelleting the forage appears to have increased its anthelmintic properties.

Table 3
Total nematodes in abomasum and small intestine of parasitized goats fed sericea lespedeza (SL) or bermudagrass (BG) hay and a small amount of concentrates

Adult nematodes	Diet			S.E.M.
	SL ground	SL pellet	BG ground	
Abomasum				
H. contortus	297[ab]	117[a]	477[b]	116
O. circumcincta	50[a]	20[a]	13[a]	17
Small intestine				
T. colubriformis	1517[a]	917[a]	1377[a]	238
Total	1863[a]	1053[a]	1867[a]	329

Row means with unlike superscripts (a and b) differ significantly ($P < 0.05$).

Shaik et al. (2006) concluded that the type of CT (molecular structure) in the plant and its reactivity may be more important than the absolute amount of extractable versus bound forms. The current investigation supports this view. Further research on effects of feed processing on the anthelmintic activity of SL is warranted, as there may be a limit to how much the feed can be heated and still maintain its nutritional or anthelmintic properties. Additional research is also needed concerning the nutritional value of processed SL hay in ruminant diets. While cattle, horses, sheep, and goats readily consume SL hay, there is relatively little data on its nutritional adequacy for livestock, and almost no information on the effects of CT in SL hay on nutrition-parasite interactions in animals.

Pelleting SL hay should add value by increasing its flexibility for feeding, storage, and shipping. Feeding pelleted feeds is common with certain classes of livestock in the USA, including horses, dairy animals (cows and goats), domestic camelids (llamas and alpacas), and as a supplement to grazing livestock in during times of poor pasture quality. Pelleted rations are also popular for feeding zoo animals. All livestock and wild hoofstock suffer from gastrointestinal parasitism, and pelleted SL hay may have potential use for parasite control in many of these situations.

5. Conclusions

Pelleting SL hay enhanced its anthelmintic effectiveness against GIN of goats and could potentially increase the utility of this forage as a natural deworming agent for small ruminants. Further research is needed to determine the potential for integrating SL pellets into a GIN control program for goats or other ruminant species.

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