The Texas Journal of Agriculture and Natural Resources 27:13-23 (2014)

Intake and Nutritional Quality of Different Types of Onions by Lambs

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ABSTRACT

Onions (*Allium cepa*) may reduce some nutritional deficiencies in ruminants. In addition, onions reportedly contain L-cysteine which may bind with the toxic compound in bitterweed (*Hymenoxys odorata*) to create a less toxic compound. We compared intake, nutritional quality, and L-cysteine levels among the types of onions. Red, yellow, or white onions were fed to Rambouillet lambs in individual pens in April, July, and November. A fourth treatment only received the basal diet of alfalfa (control). Intake was monitored daily. Weights were taken at the beginning and at the end of the trial. Packed cell volume was measured in each feeding trial to assess anemia. During the April trial, serum metabolite levels, that are indicative of toxicosis, were also measured. Intake of onions and alfalfa were similar (P > 0.05) among treatments. Packed cell volume was lower (P < 0.05) for lambs fed alfalfa alone in April, but was similar among all treatments in July and November. L-cysteine levels were undetected when measured in April. Serum metabolite levels remained within normal levels. Nutritional quality was also similar among types of onions. Lambs readily consumed onions and avoided toxicosis even when onions made up 100% of the diet.

Key Words: *Hymenoxys Allium*, onions, cysteine, supplementation

INTRODUCTION

Onions that do not enter into the human food chain are sometimes fed to livestock. In West Central Texas, there is some interest in feeding onions to sheep as a supplemental feed and to reduce the likelihood of bitterweed (*Hymenoxys odorata*, DC.) toxicosis. Bitterweed is considered one of the most problematic plant species in western Texas (Hardy et al. 1931), especially in the Edwards Plateau region. Since the early 1920's, bitterweed has been recognized as being poisonous to sheep (Sperry 1949) and was reported to be the most serious toxic plant problem faced by sheep producers in Texas (Calhoun et al. 1980).

The toxin in bitterweed is a sesquiterpene lactone known as hymenoxon (Kim et al. 1975; Ueckert and Calhoun 1988). Symptoms of hymenoxon poisoning include bloat, central nervous system recession, termination of rumen activity, kidney damage, liver

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damage, and eventually death (Rowe et al. 1973; Witzel et al. 1974). Hymenoxon conjugates in the rumen with sulfhydryl groups, forming a less toxic compound (Calhoun et al. 1989). The amino acid L-cysteine contains sulfur and may provide sulfhydryl groups for conjugation in the rumen. Rowe et al. (1980) dosed sheep with cysteine, increasing the survival rate up to 12-fold over sheep that were not dosed. Onions (*Allium cepa*, L.) contain moderate to high levels of cysteine. Some report that sheep will readily consume onions when fed a 100% onion diet and can perform as well on the onions as on a grain diet (Knight et al. 2000), while others caution that onion toxicity can occur with over-ingestion causing anemia in animals (Cheeke 1998).

Different onion types differ in phenolic content, antioxidant, and anti-proliferative activities (Yang et al. 2004). Changes in the concentration and total amount of flavor precursors like S-alk(en)yl-L-cysteine sulphoxides during the growth of an onion should affect the flavor and potentially the level of L-cysteine in onions (Lancaster et al. 1983). This may explain why some report ruminants will readily consume onions without any adverse effects (Campbell et al. personal communication) while others report that ruminants are reluctant to consume onions (Bundick 2008). Campbell et al. also reported that onions reduced the likelihood of bitterweed toxicosis, while Bundick (2008) showed that onions did not offer any protection from bitterweed toxicosis. Accordingly, this study assessed intake of different onion types by lambs, differences in nutritional quality, and L-cysteine levels between types of onions. The study also determined if an intake of onions resulted in anemia or soft tissue damage from toxicosis.

MATERIALS AND METHODS

This study consisted of three trials that were conducted at the Angelo State University Management Instruction and Research (MIR) Center. Trial 1 was conducted in April 2009. Trial 2 was conducted in July 2009 and Trial 3 was conducted in November 2009. During each trial, lambs were randomly allocated to treatments, with each treatment fed a different type of onion (red, yellow, or white).

Forty recently weaned Rambouillet lambs (46.6 kg) were randomly allocated to four treatments (n = 10/treatment). The lambs were separated into individual pens (1 X 1.5 m) and allowed 5-10 days for pen adjustment. Alfalfa pellets were fed at 2.5% BW to meet the animal's maintenance requirements as specified by the National Research Council (2007). Lambs received fresh water and a calcium/phosphorus mineral *ad libitum*, and excreta were removed weekly. The research protocol was approved by the Angelo State University Animal Care and Use Committee.

After the adjustment period, lambs were fed onions daily for 22 days. The first treatment was supplemented with red onions, the second with white onions, the third with yellow onions, and the fourth treatment served as the control group receiving only alfalfa pellets. During the 22-day study, the onions were chopped by hand and offered from 1,300 to 1,400 each afternoon. The amount of onions fed began at 75 g. Once an individual lamb consumed all onions for two consecutive feeding bouts, the amount was increased by 25 g until the point of refusal. All the lambs received the 2.5% BW alfalfa after the onions had been offered to meet maintenance requirements.

Any changes in weight, blood serum levels, and packed cell volume (PCV) were recorded during this experiment to monitor for any signs of toxicosis. Serum metabolite levels and packed cell volume were monitored at days 0, 10, and 22. Changes in serum levels indicative of toxicosis include levels of serum aspartate transaminase (AST), blood urea nitrogen (BUN), gamma glutamyltrasferase (GGT), creatinine, and bilirubin (Cornelius 1989; Cheeke 1998). Blood was collected via jugular vein-puncture, serum extracted by centrifugation (3,000 rpm for 20 minutes), frozen (-80 ^{o}C), and sent to the Texas Veterinary Medical Diagnostic Lab in College Station, Texas, for chemical analysis. Packed cell volume was measured as a percent of red blood cells (RBC) by transferring fresh blood in capillary tubes 30 minutes after collection, then centrifuging the tubes for 15 minutes and measuring the red blood cells with the scale affixed to the centrifuge. All lambs were weighed at the beginning and end of the study to assess any variation in weight among treatments.

Subsamples of each type of onions were analyzed for crude protein, digestibility, Acid Detergent Fiber, Neutral Detergent Fiber, Net Energy for maintenance (NEm), and moisture content by Dairy One in Ithaca, New York. Another subsample of each onion was sent to NP Analytical Labs in St. Louis, MO for L-cysteine levels.

In July 2009, a second trial was conducted and consisted of 32 (n = 8/treatment) recently weaned Rambouillet lambs (36.5 kg). The purpose of the second trial was to determine if the trends observed in the first trial, particularly the differences in PCV, would be repeated. The treatment groups and feeding protocol were identical to Trial 1. Serum levels were not measured in Trial 2, but packed cell volume (PCV) was measured. Blood samples were collected and centrifuged to measure PCV levels using the same methods as in the first trial. L-cysteine levels of the onions in Trial 2 were not measured because levels were undetectable in Trial 1; however, nutritional analysis was measured. Intake of onions and alfalfa were measured throughout the study. Lambs were also weighed at the end of the feeding period to evaluate weight gain/loss.

In November 2009, freshly weaned Rambouillet lambs (33.4 kg) were fed the three types of onions in the same manner as the first two trials. Lambs were randomly allocated to one of four treatments, which corresponded with the first two trials. Initially, the trial consisted of 40 lambs (n = 10/treatment), but one died of natural causes six days into the trial. This trial differed from the first two trials in that the amount of basal ration was reduced systematically throughout the trial until lambs were consuming a diet that consisted of 100% onions.

For the first 14 days, alfalfa was offered at 2.5% BW after onions were offered. Onions were offered initially at 75 g, and once complete onion consumption was achieved, the onions were increased by 25 g each subsequent day. During days 15-21, alfalfa was decreased to 2% BW. Alfalfa levels were again decreased on days 22-28, 29-35, and 36-42 to 1.5%, 1%, and 0%, respectively. The control group received 2.5% BW alfalfa throughout the duration of the trial.

Intake of onions and alfalfa were monitored daily along with packed cell volume. Packed cell volume was evaluated on days 0, 17, 24, 31, 38, and 45. Blood was collected via jugular vein-puncture, placed in capillary tubes then centrifuged and measured to obtain the packed cell volume. Body weight was measured at the beginning and end of the trial.

This study design was a completely randomized design. Differences between the types of onions were assessed using repeated measures analysis of variance. The individual lambs nested within treatments served as replications, and the day of observation was the repeated measure. Means were separated using Tukey's LSD where $P < 0.05$ was considered significant. Each trial was analyzed separately using the statistical package JMP (SAS Institute 2007).

RESULTS

April 2009. In Trial 1, the intake of onions and alfalfa was similar (P > 0.05) among treatments (Table 1). Lambs were hesitant to consume onions initially, but intake increased for all three treatments across the days of feeding. By the end of the study, intake varied among treatments (treatment by day interaction; P < 0.05) (Fig. 1). By the end of the trial, the lambs were consuming on average 2.4 g · kg^{-1} BW of onions per day in each treatment.

Table 1. Average intake (g · kg $^{-1}$ BW) of onions and alfalfa by lambs receiving different onion types in April, July, and November.

		Treatment			
Food Item		Red	White	Yellow	SEM
April					
	Onions	0.9	1	1.2	0.2
	Alfalfa	10.6	11.1	11.2	0.3
July					
	Onions	1.4	1.2	1.2	0.3
	Alfalfa	25	24.7	21.9	1.8
November					
	Onions	20.6	23.4	21.8	1.3
	Alfalfa	16.3	16.3	16.3	0.01

[1]The amount of onions offered was increased over the trial until onions made up 100% of the diet.

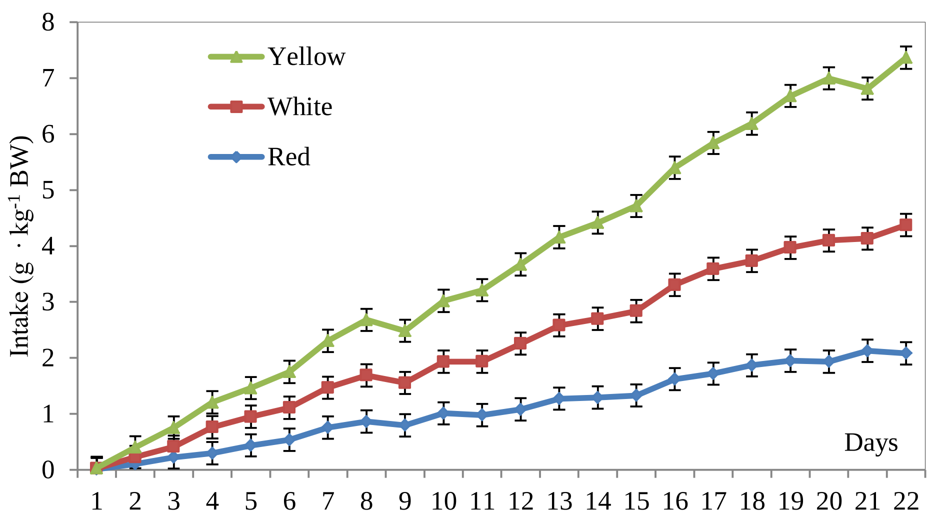

Figure 1. Average daily onion intake (g · kg^{-1} BW) by lambs during April. The treatment X day interaction differed (P < 0.05).

Some serum levels differed among treatments and days, but remained within normal ranges for healthy animals (Tables 2 and 3). Creatinine levels differed between the control and the treatment receiving yellow onions. Gamma glutamyltrasferase (GGT) levels from Day 1 collection period differed from the Day 11 and Day 22 collections (Table 3).

Table 2. Average serum metabolite levels of lambs within treatments in the April trial.

	Treatment					
Serum Metabolite	Red	White	Yellow	Control	SEM	Normal Range[1]
GGT (U/l)	73.7	65.1	61.2	62.1	4.8	34-82
AST (U/l)	114.8	112.5	89.9	110.1	6.9	51-130
Creatinine(mg/dl)	0.74[ab]	0.72[ab]	0.64[b]	0.74[a]	0.03	03-1.3
BUN (mg/dl)	24	23.5	22.3	24.8	0.8	12-32
Glucose(mg/dl)	58.1	60.4	59.8	61	2.3	58-109

[ab] Superscripts that differ are significantly different (P < 0.05)
[1]Normal range as reported by the Texas Veterinary Medical Diagnostic Laboratory, College Station, Texas.

Table 3. Serum metabolite levels of lambs in April by collection day. Data were pooled across all treatments because of a lack of treatment effect (P > 0.05).

Serum Metabolite	Collection Day		
	Day 1	Day 11	Day 22
GGT (U/l)	73.9[a]	60.7[b]	62.0[b]
AST (U/l)	120.2[a]	118.0[a]	82.3[b]
Creatinine(mg/dl)	0.6[c]	0.8[a]	0.7[b]
BUN (mg/dl)	23.8[b]	21.6[c]	25.6[a]
Glucose(mg/dl)	76.7[a]	58.6[b]	44.1[c]

[abc] Superscripts that differ are significantly different (P < 0.05)

Regardless of their treatment diet, none of the lambs in the April trial exhibited signs of anemia. Packed cell volume counts were similar among lambs fed either red, white, or yellow onions and remained within the normal range for healthy animals (Table 4). When compared to the control treatment, PCV was higher (P < 0.05) for lambs receiving onions. Weight change was similar (P > 0.05) among treatments (Table 5).

July 2009. In July, alfalfa and onion intake were similar (P > 0.05) among the three treatments (Table 1). Once again, the lambs were initially reluctant to consume onions, but intake for all three treatments increased across the days. By the end of the study, intake differed by treatments (treatment by day interaction differed; P < 0.05) (Fig. 2). Lambs in the onion treatments were consuming on average 3.9 g · kg^{-1} BW of onions by the end of the trial.

Table 4. Packed cell volume (PCV) for sheep supplemented with either onions or no supplement in April, July, and November.

Treatment	Packed Cell Volume	SEM
April		
Red	37.9	0.9
Yellow	38.4	0.9
White	38.3	0.9
Control	35.1	0.9
July		
Red	35.2	2.3
Yellow	29.5	2.3
White	29.9	2.3
Control	34.3	2.3
November		
Red	37.1	0.8
Yellow	34.8	0.8
White	36.8	0.8
Control	37.4	0.8

Serum constituents were not measured in Trial 2 because all metabolites remained within normal levels in April. Packed cell volume counts were similar (P > 0.05) and within the normal range among all treatments in July (Table 3). Weight change was also similar (P > 0.05) among treatments (Table 5).

Table 5. Average weight (kg) for lambs supplemented with either onions or no supplement in April, July, and November. Weights were taken at the beginning and end of each trial.

Treatment	Beginning	End	SEM
April			
Red	45.7	43.5	3.2
White	46.1	44.0	3.2
Yellow	45.8	43.8	3.2
Control	46.5	44.5	3.2
July			
Red	37.3	33.8	2.4
White	34.3	29.2	2.4
Yellow	35.2	30.0	2.4
Control	39.1	36.0	2.4
November			
Red	33.0^{a}	29.2^{b}	1.1
White	32.6^{a}	27.3^{b}	1.1
Yellow	31.9^{a}	27.0^{b}	1.1
Control	36.2^{a}	36.2^{a}	1.1

^{ab} Superscripts that differ are significantly different (P < 0.05)

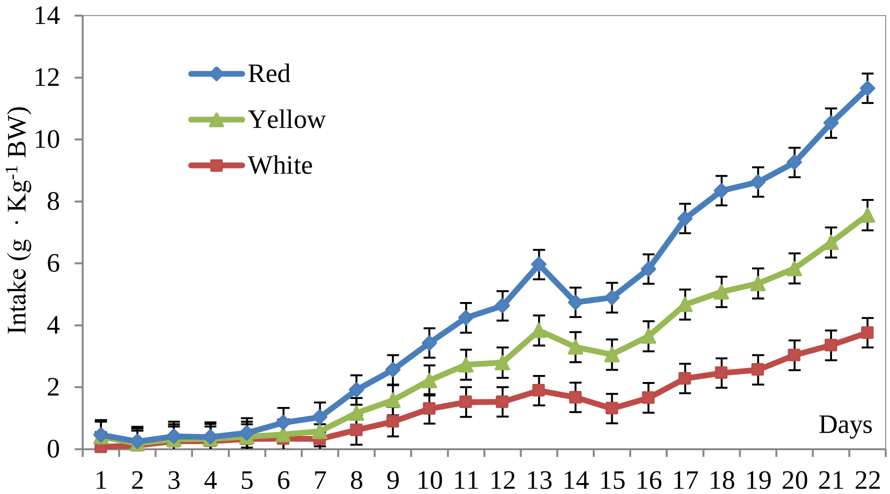

Figure 2. Average daily onion intake by lambs (g · kg^{-1} BW) during July.

November 2009. In Trial 3, the intake of onions and alfalfa were similar ($P > 0.05$) among all treatments (Table 1). As the alfalfa was decreased, onion consumption increased to meet the nutritional demands that the alfalfa had filled (Fig. 3). The treatment X day interaction did not differ ($P > 0.05$). By the end of the trial, the lambs were consuming on average 49.4 g · kg^{-1} BW of onions per day.

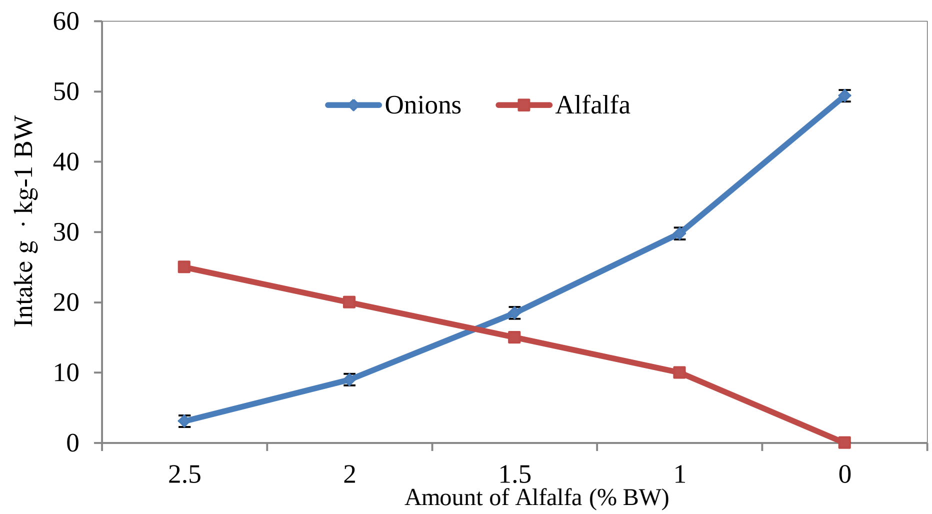

Figure 3. Onion and alfalfa intake (g · kg^{-1} BW) of lambs for November.

Packed cell volume for Trial 3 was similar ($P > 0.05$) among all treatments (Table 4). The packed cell volume increased from initial collection to the final collection period during the trial (significant day of collection; $P < 0.05$) (Fig. 4). Weight change was also similar ($P > 0.05$) among the onion treatments with an average loss of 1.4 to 1.8 kg; the control maintained a constant weight throughout the trial (Table 5).

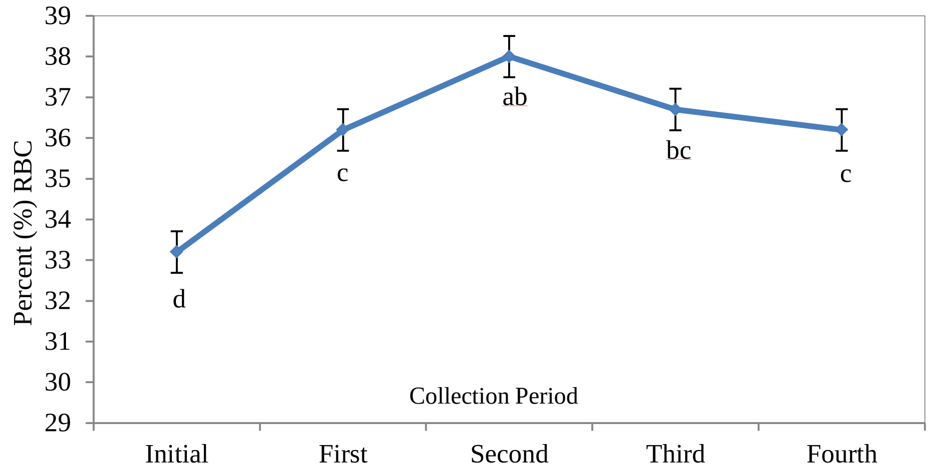

Figure 4. Packed cell volume (% RBC) by collection period for Trial 3.
abcd Superscripts that differ are significantly different

Nutritional Analysis. Onions in all three trials revealed no nutritional differences between the three types that were offered for any of the variables measured (Table 6). Onions appear to be a moderately to highly nutritious supplemental feed.

Table 6. Nutritional analysis of the three onion types for the spring, summer, and winter trials.

	April			July			November		
Nutrient	Red	White	Yellow	Red	White	Yellow	Red	White	Yellow
Crude Protein (%)	14.0	13.4	11.5	8.6	11.3	9.3	15.2	10.8	12.7
NDF (%)	13.3	10.4	9.5	19.6	17.5	14.8	13.3	7.7	14.1
ADF (%)	9.7	9.9	8.4	14.9	13.8	11.0	10.0	6.7	12.0
NEM, (Mcal/lb)	0.88	0.89	0.90	0.84	0.85	0.87	0.88	0.91	0.87

CONCLUSION AND DISCUSSION

Results of this study indicate that lambs have no clear preference for any one of the three types of onions (red, yellow, and white) used in this study. By the end of the spring and summer trials, intake differed among types of onions (treatment by day interaction differed). In the spring trial, intake was highest of yellow onions, followed by white and red onions. For the summer trial, intake was highest for red onions, followed by yellow and white onions. Thus, there was no clear pattern of preference for one type of onion over the others. Nutritional quality of the three types was also similar in all three trials. Lambs quickly adapted to eating onions and readily consumed onions in all three trials without exhibiting any signs of toxicosis or anemia.

Toxicity from onions may have been avoided in this study because lambs were introduced slowly to onions over 14 days. We began by feeding small amounts (75 g) and increasing the amount offered slowly ($25\ g \cdot hd^{-1} \cdot day^{-1}$). Digestive physiology can be altered through exposure to poisonous plants early in life to the point that ruminants can avoid toxicosis. This observation was first illustrated by Distel and Provenza (1991). Goats, at six weeks of age, were fed blackbrush (*Coleogne ramosissima* Torr.) daily. Goats introduced to blackbrush early in life consumed 95% ($P < 0.01$) more blackbrush than naïve goats, were more efficient at digesting blackbrush, and excreted more uronic acid apparently because of an increased ability to detoxify the tannins in blackbrush.

Recent research with redberry juniper suggests that goats may be adapting to the toxic monoterpenoids in the plant as well (Bisson et al. 2001; Ellis et al. 2005; Dunson et al. 2007). These studies exposed goats to juniper in a pen situation for 14 days to allow for adaptation to the monoterpenoids in the plant. Goats typically increased intake up to 30% of the diet without experiencing any adverse effects from toxicosis. It is unclear if adaptation to toxic compounds in onions occurred in this study. Furthermore, the mechanism of the detoxification of onions is unclear.

In many other regions of the U.S., cull onions are used as a supplemental feed (McBride 2004). Onions reportedly range from 9-13% crude protein, 83-90% TDN, 0.35% Ca, 0.40% P, and 0.97 NE_m with a water content of 90% (Lardy and Anderson 2003). The onions in this study had crude protein levels ranging from 8-15%, NE_m from 0.84-0.91%, and 77-81% TDN, with moisture content of 90%. Calcium and phosphorus were not measured in this study. Ruminants need around 6-8% crude protein to maintain a healthy rumen, which onions easily could supply especially during winter when forage quality is limited.

Onions are apparently high in L-cysteine. We attempted to measure L-cysteine levels in the onions in April, but levels were undetectable. Dosing with L-cysteine has been shown to increase bitterweed intake while allowing animals to avoid hymenoxon-induced toxicosis (Rowe et al. 1980; Calhoun et al. 1986). Given onions' apparent levels of L-cysteine, others have suggested that onions may be an effective supplement to attenuate bitterweed toxicosis. In a preliminary trial, serum metabolite levels that are indicative of toxicosis were lower ($P < 0.05$) in lambs supplemented with onions (Campbell et al. unpub. data). Conversely, Bundick (2008) reported that supplementation with onions did not improve intake. Reasons for the differences in results remain unclear. However, Campbell et al. was able to get sheep to consume a diet consisting of 75% onions while Bundick (2008) was not.

Bundick (2008) also supplemented sheep with soybean meal which is high in L-cysteine in an attempt to increase the intake of bitterweed. Intake of bitterweed did not increase with soybean meal supplementation. Conversely, Coffman (2009) used four high-protein feeds (soybean meal, soybean meal/dried distillers grain, cottonseed meal, and cottonseed meal/dried distillers grain) to increase bitterweed intake. Supplementation with soybean meal increased intake of bitterweed while apparently allowing sheep to avoid bitterweed toxicosis.

Based on the results of this study, onions could serve as a viable supplement for sheep. Sheep readily consumed onions, but lost some weight when fed a diet of 100% onions. All three onion types are nutritious, and if intake is increased slowly, onion toxicity should not occur.

ACKNOWLEDGEMENTS

Research reported herein was supported by University Lands and the Angelo State University Management, Instruction, and Research Center.

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