沙漠研究 **25**-3, 177 -180 (2015)
Journal of Arid Land Studies

- ICAL 2 Refereed paper -

Frothy Bloat (primary ruminal tympany) Potential and Nutrient Content of Forage Kochia (*Bassia prostrata* L.)

Teshome SHENKORU [1)], Antonio FACIOLA [1)], Brad SCHULTZ [2)] and Barry PERRYMAN*[1)]

Abstract: Forage kochia (*Bassia prostrata* L.) has been used extensively by grazing animals in Central Asia. Forage kochia was introduced into the U.S.A. in 1966 from a Stavropol Botanical Gardens (USSR) planting, and released as a cultivar (Immigrant) in 1984. It has been included in fire and rangeland rehabilitation seed mixes and planted on at least 200,000-400,000 ha in the USA. However, in central Nevada (USA), it has been linked to cattle mortality by frothy bloat (primary ruminal tympany) under specific ecological site conditions. In order to assess its potential to cause frothy bloat in free roaming cattle, we investigated the nutritive value of forage kochia across a grazing season (September-January), and compared in vitro gas production, and foam production and strength with fresh alfalfa. Crude protein values were highest in October-November (23.3 and 21.5%, respectively), while NDF was lowest during the same period (38.8 and 39.3%, respectively). Gas and foam production were higher for alfalfa than kochia over a 12 h incubation period. In general, alfalfa produced twice as much gas and foam as forage kochia ($P<0.001$). However, forage kochia foam strength (g/DM) was double that of alfalfa ($P<0.002$), and by 6 h incubation time, foam height of forage kochia was twice that of alfalfa ($P<0.001$). Forage kochia when used as the sole forage in the diet has the potential to cause frothy bloat in cattle. Fresh alfalfa produces more gas in the rumen; however, foam from forage kochia digestion is likely to be more persistent, potentially leading to frothy bloat development.

Key Words: *Bassia prostrata*, Foam strength, Frothy bloat.

1. Introduction

Forage kochia (*Bassia prostrata* L.) has been used extensively by grazing animals for millennia in Central Asia (Harrison *et al*., 2000; Waldron *et al*., 2005). It has high crude protein content during the critical fall/winter grazing period (Davis and Welch, 1985; ZoBell *et al*., 2003; Waldron *et al*., 2006), non-toxic levels of oxalates (Davis, 1979), and acceptable digestibility and relatively high preference (Welch and Davis, 1984; Stevens *et al*., 1985; ZoBell *et al*., 2003).

In 2005, some ranchers in central-Nevada, USA began reporting problems with frothy bloat in cattle, which can be fatal. After a large mortality incident in October 2005, necropsies were performed on several head of cattle and the cause of death was asphyxiation related to frothy bloat (primary ruminal tympany). Frothy bloat is defined as the entrapment of the normal gases of fermentation in a stable foam within the ruminant animal foregut (Irsik, 2007). Unlike free gas bloat where large pockets of gas accumulate, in frothy bloat gases are retained within the forage digesta creating foam or froth that cannot be belched since a free pocket of gas never develops.

Upon further investigation, it was determined that the deceased animal rumens contained large quantities of forage kochia, and that the animals had been grazing in a location where forage kochia had been established as a fire rehabilitation seeding. A subsequent mortality incident, in October 2012, lead to the same conclusions.

Because of the seasonality of forage kochia, it is often the only available, green, high crude protein source during the fall and early winter grazing period. Forage kochia also has very small leaves that increase the potential for gasses and foam to be retained in the rumen digesta. Mortality of cattle translates into lower profitability for ranchers. Economically marginal operations like many in Nevada cannot afford mortality losses from grazing related incidents that can be easily corrected or eliminated.

The primary goal of this study was to assist Nevada ranchers in dealing with a rangeland management problem associated with cattle consuming forage kochia. In order to achieve this goal, our specific objectives were: 1) investigate the nutritive content of forage kochia harvested during the fall/winter grazing season period, by chemical analyses; and 2) compare kochia (October sample) with fresh alfalfa for frothy bloat potential by measuring gas production, foam production, and strength, using in vitro digestion.

2. Materials and Methods

The nutritive content of forage kochia was assessed in fall/winter of 2011-12 by one-way ANOVA using months as treatments (Sept., Oct., Nov., Dec. and Jan.). Variables of interest included: dry matter (DM) (AOAC, 2000), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), ether extract (EE)

* Corresponding Author: bperryman@cabnr.unr.edu
Mail Stop 142, University of Nevada-Reno, Reno, Nevada 89557, USA
(Received, July 22th, 2012; Accepted, November 29th, 2012)
1) Department of Agriculture, Nutrition, and Veterinary Sciences, University of Nevada-Reno 2) College of Extension, University of Nevada-Reno

and in vitro dry matter digestibility (IVDMD) (Jeraci *et al.*, 1988).

Gas production (Min *et al.*, 2005a, 2005b) was assessed with a 2 × 7 factorial ANOVA using forage kochia (October samples), fresh alfalfa, and seven incubation times (1, 2, 3, 4, 5, 6 and 12 h). Gas production was modeled according to Ørskov and McDonald (1979) using the model:

$$Y = b\,(1 - e^{-ct})$$

Where:

Y = volume of gas produced within time (t).

b = potential extent of gas production.

c = gas production rate, expressed in percent/h.

The intercept is not included in the model with the understanding that no gas is produced from unfermented feed.

Foam production characteristics were assessed using a 2 × 3 factorial ANOVA that included both forage kochia (October samples), fresh alfalfa, and three incubation times (0, 2 and 6 h). Response variables included foam production (height in cm per g of DM) and foam strength (Mangan, 1959; Pressey *et al.*, 1963; Min *et al.*, 2005a, 2005b). Foam strength was calculated using the formula: foam strength = 100 × time of fall/distance of foam drop (Mangan, 1959). Forage kochia used in the gas and foam assessments was collected only in October of 2011.

Data were analyzed with Statistical Analysis Software version 9.2 (SAS, 2010) and differences determined at $P < 0.05$ for all analyses. Post-hoc comparisons were performed using least significant difference (LSD).

3. Results and Discussion

3.1. Nutritive content of *Bassia prostrata*

Actual values are presented in **Table 1**. The highest CP content (P<0.0001) was observed on samples collected in Oct. and Nov. of 2011 (23.3 and 21.5%, respectively); while the lowest value was recorded in Jan., 2012 (10.1%). Values for NDF, ADF and ADL fractions were the lowest during Oct. and Nov. (*P*<0.02), while their values were higher during Sept. and Jan. Value of EE was significantly (*P*< 0.0001) higher in November than the rest of the assessment period. IVDMD was highest (*P*<0.003) in October, and lowest (*P*<0.05) in December and January.

CP levels reported here are higher than those reported by Schauer *et al.* (2004) and Waldron *et al.* (2006). Differences between trials may be the result of differences among climates, soils or stand maturity. Values of CP declined as plants matured and senesced between Oct. (23.3%) and Jan. (10.1%). However, the CP content was above the minimum of 7% required to maintain rumen function (NRC, 2000). This characteristic indicates that forage kochia has great potential as a fall/winter protein source for grazing beef cows in the western USA.

Table 1. Mean nutritive content (% of DM) and standard error (SE) of Bassia prostrata across the grazing season 2011-2012. Means in the same row with different letters are significant at *P*< 0.05.

%	Sept	Oct	Nov	Dec	Jan	SE
DM	93.4	95.2	94.5	96.2	95.8	0.24
CP	15.9b	23.3a	21.5a	16.8b	10.1c	1.02
NDF	45.4b	38.8c	39.3c	42.3c	54.6a	1.85
ADF	27.8ab	19.1c	20.4c	26.3b	31.6a	1.66
ADL	7.3a	6.2b	5.9b	7.2a	7.5a	0.21
EE	1.5e	2.6c	5.6a	3.3b	2.1d	0.17
IVDMD	54.0ab	57.9a	48.8b	42.8c	41.1c	2.12

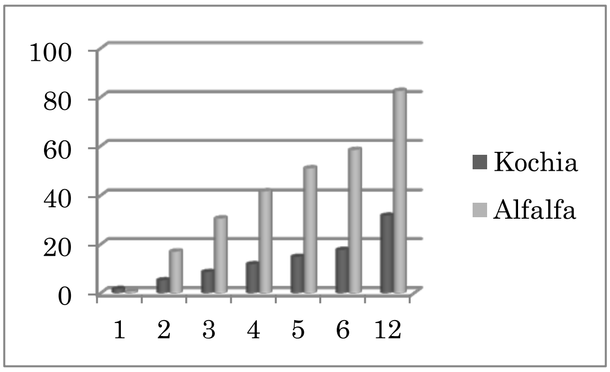

Fig. 1. Cumulative, in vitro gas production from forage kochia (*Bassia prostrata*) and fresh alfalfa for seven incubation periods, 2011. Vertical axis = Gas production (ml/gDM); Horizontal axis = incubation time (h).

3.2. Gas production

The cumulative in vitro gas production from forage kochia and alfalfa are displayed in **Figure 1**. With the exception of 1h, alfalfa gas production was continuously greater than forage kochia (*P*<0.001). This is due in part to its lower NDF content (27.5 vs. 38.6%), and greater amounts of fermentable products, relative to forage kochia.

3.3. Foam production and strength

Foam production (measured as height in cm per g of DM) by time responses are shown in **Table 2**. An interaction was observed between forage species and incubation time (*P*<0.05). The interaction is an artifact of comparatively low foam height at 6 h versus 2 h fermentation time. Alfalfa foam production was higher at 0 and 2 h fermentation time than forage kochia (*P*<0.001). However, the lowest foam production observed for alfalfa was at 6 h fermentation time.

Kochia had significantly higher foam strength than alfalfa (*P*<0.002; **Fig. 2**). This is most likely due to the smaller bubbles observed for kochia during fermentation process. Smaller bubbles have higher internal pressure than larger bubbles, which provides greater resistance against collapse

Table 2. Effect of time (h) by species on in vitro ruminal foam height (cm per g of DM) for forage kochia (Oct. samples and fresh alfalfa, 2011. Means in the same row with different letters are significant at $P< 0.05$ (SE: 15.1).

	Forage Kochia			Alfalfa		
	Time (h)			Time (h)		
	0	2	6	0	2	6
cm	75c	107b	98bc	193a	168a	43d

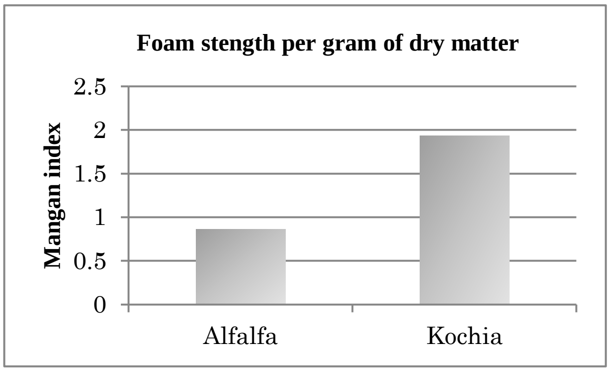

Fig. 2. Foam strength of fresh alfalfa and *Bassia prostrata*.

(Busaryev *et al*., 2012).

Since movement in the rumen is fairly continuous, persistent foam would be expected to provide considerable resistance to mechanical stress, and a greater ability to retain entrapped gases. Alfalfa produced more gas and foam than forage kochia; however, the larger bubbles associated with it disappeared at a much faster rate than with forage kochia.

Another factor leading to the more substantial foam of forage kochia could be the attraction between soluble proteins that are negatively charged, and positively charged mineral ions present in the rumen fluid. This can increase the stability and strength of foams (Moeller *et al*., 2012), the authors stated that divalent and trivalent ions can form bonds with two or three negatively charged protein particles, thereby creating a more stable foam when compared to sodium, a monovalent ion. Although we did not determine mineral contents of the test forages, according to Karimi *et al*. (2005) mineral analysis of forage kochia showed 39 mg/g potassium, and 7.3 mg/g magnesium, while alfalfa contains only 26 mg/g potassium and 2.8 mg/g magnesium (NRC, 2000). The high concentration of these minerals in forage kochia likely contributed to its greater foam stability. Additionally, high concentrations of K and Mg are associated with occurrence of bloat in cattle (Stifel *et al*., 1968).

4. Conclusions

Results of this study indicate that forage kochia (*Bassia prostrata*) when consumed as the sole forage in the diet has the potential to cause frothy bloat in ruminant animals. Even though alfalfa produced more fermentation gases, forage kochia produced more persistent foam in terms of strength and residence time. Given this potential, we can offer some simple guidelines for producers that utilize forage kochia as a fall grazing resource: 1) When possible, do not introduce ruminants into forage kochia seedings when it is actively growing during the fall; 2) If animals must be placed in these areas, offer grass hay or other dry forages to buffer the bloat effects; and 3) Offer anti-bloat supplements before moving and after arrival into forage kochia seedings.

Acknowledgements

This research was funded by the University of Nevada-Reno Agriculture Experiment Station and the College of Agriculture, Biotechnology, and Natural Resources.

References

AOAC (2000): *Official Methods of Analysis. 7th ed.*. Association of Official Analytical Chemist, Gaithersburg, MD.

Busaryev O., Dey T., Wang H., Ren Z. (2012): Animating bubbles interaction in liquid foam. *ACM Transactions on graphics*, **63**: 1-8.

Davis A.M. (1979): Forage quality of prostrate Kochia compared with three browse species. *Agronomy Journal*, **71**: 822-824.

Davis J.N., Welch B.L. (1985): Winter preference, nutritive value, and other range characteristics of *Kochia prostrata* (L.). *Great Basin Naturalist*. **45**:778-783.

Harrison R.D., Chatterton N.J., Waldron B.L., Davenport B.W., Palazzo A.J., Horton W.H., Asay K.H. (2000): *Forage Kochia - Its compatibility and potential aggressiveness on intermountain rangelands*. Logan UT: Utah State University. *Utah Ag. Exp. Sta. Res. Rpt*. 162.

Irsik M.B. (2007): *Bloat in cattle. University of Florida IFAS Extension Bulletin VM164*.

Jeraci J.L., Hernandez T., Robinson J.B., Van Soest P.J. (1988): New and improved procedure for neutral detergent fiber. *J. Anim. Sci.*, **66** (Supplement 1): 351.

Karimi K., Ghorbanli M.., Heidari H., Khavarinejad R.A., Assareh M.H. (2005): The effect of NaCl on growth, water relations, osmolytes and ion content in *Kochia prostrata*. *Biologia plantarum*, **49**: 301-304.

Mangan, I.L. (1959): Bloat in cattle. *New Zealand Journal of Agricultural Research*, **2**: 47-61.

Min B.R., Pinchak W.E., Fulford J.D., Puchala R. (2005a): Effects of feed additives on in vitro and in vivo rumen characteristics and frothy bloat dynamics in steers grazing wheat pasture. *Animal Feed Science Technology*, **123-124**:615-629.

Min B.R., Pinchak W.E., Fulford J.D., Puchala R. (2005b): Wheat pasture bloat dynamics, *in vitro* ruminal gas production, and potential bloat mitigation with condensed tannins. *J. Anim. Sci.*, **83**:1322-1331.

Moeller L., Goersch K., Neuhaus J., Zehnsdorf A., Mueller R.A. (2012): Comparative review of foam formation in biogas plants and ruminant bloat. *Energy, Sustainability and Society*, **2**: 12.

NRC (National Research council) (2000): *Nutrient requirement of beef cattle, seventh ed*. National Academy Press, Washington, D.C. USA.

Orskov E.R., McDonald I. (1979): The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *Journal of Agricultural Science*, **92**: 499-503.

Pressey. R., Synhorst S.H., Allen R.S., Jacobson N.L., Wilsie C.P. (1963): Pectic substances in in forages and their relationship to bloat. *J. Agric. Food Chem.*, **11**:396-399.

Schauer C.S., Bohnert D.W., Carpinelli M.F., Falck S.J. (2004): Forage kochia may be a complimentary forage to most dormant cool-season grasses in the intermountain-West. *Rangelands*, **26**:8-11.

SAS. (2010): *SAS Users's Guide: Statistics, Version 9.2*. SAS Institute,

Cary, NC, USA.
Stevens R.K., Jorgensen R., McArthur E.D., Davis J.N. (1985): Immigrant forage kochia. *Range*, **7**:22-23.
Stifel F.B., Vetter R.L., Allen R.S. (1968): Relationship between calcium and magnesium binding to fraction I chloroplast protein and bloat. *J. Agri. Food Chem.*, **16**: 501-504.
Waldron B. L., Harrison R.D., Rabbimov A., Mukimov T., Yusupov S.Y., Tursvnova G. (2005): Forage kochia: Uzbekistan's desert alfalfa. *Rangelands*, **27**:7-12.
Waldron B.L., ZoBell D.R.., Olson K.C., Jensen K.B., Snyder D.L. (2006): Stockpiled forage kochia to maintain beef cows during winter. *Rangeland Ecol. Manage.*, **59**: 275-284.
Welch B.L., Davis J.N. (1984): In vitro digestibility of kochia prostrata (L.). *Great Basin Naturalist*, **44**: 296-298.
ZoBell D.R., Waldron B.L., Olson K.C., Harrison R.D., Jensen H. (2003): *Forage kochia for fall/winter grazing*. Utah State Univ. Ext. Pub. AG-2003-07.