

Propionic acid effects on nutritive value and fermentation characteristics of sunn hemp silage

J.M.B. Vendramini^{1,2}, H. M.S. da Silva², M. Kaneko³, P. Moriel², L. Ferraretto⁴, M.L. Silveira², J.T.L. de Sousa⁵, V. Miranda⁶ and J. Garzon⁷.

¹Texas AgriLife Research and Extension Center, Stephenville, TX, USA ²Range Cattle Research and Education Center, University of Florida, Ona, FL, USA ³Kyusyu Okinawa Agricultural Research Center, NARO, Kumamoto, Japan
⁴University of Wisconsin, Madison, WI, USA. ⁵Universidade Federal do Tocantins, Araguaina, TO, Brazil ⁶Universidade Estadual Paulista, Botucatu, SP, Brazil ⁷University of Maine, Orono, ME, USA

INTRODUCTION

➤Sunn hemp (*Crotalaria juncea* L.) is a warm-season annual legume that has been widely used as a cover crop due to the rapid growth, potential to decrease soil nematode population, and ability to fix atmospheric N (Cook & Scott, 1998). Sunn hemp has also been used as forage for livestock due to acceptable forage quality (Garzon et al. 2021).

➤Silage is a commonly used forage conservation practice in tropical and subtropical areas due to excessive rainfall during the growing season. However, limited concentration of water-soluble carbohydrates (WSC) and high buffering capacity are unfavorable characteristics of warm-season legumes to produce silage with desirable fermentation characteristics. Therefore, it is necessary to explore management practices to improve fermentation and preservation of warm-season annual legumes.

➤Propionic acid is an effective antimycotic agent and has been used to inhibit undesirable microorganisms and improve aerobic stability of corn silage. Kung et al. (1998) observed that propionic acid was effective to reduce the heating in corn silage and total mixed rations. However, there are limited reports in the literature about the effects of propionic acid in warm-season legume silage. Some producers apply additives containing propionic acid and other antifungal components in the TMR prior to feeding; however, Kung et al. (1998) suggested that controlling yeast at the time of ensiling is more efficient than trying to control their numbers and metabolism in the feed bunk.

OBJECTIVES

➤The objective of this study was to evaluate the use of propionic acid to improve nutritive value and fermentation characteristics of sunn hemp silage.

MATERIAL AND METHODS

➤The research was conducted at the Range Cattle Research and Education Center, Ona, FL (27°31'N e 81°51'W) from May to November 2018. Fifteen experimental units (plots) of 'Ubon' sunn hemp were seeded in a prepared seedbed in May 2018 with a seeding rate of 25 kg ha⁻¹. Plots were 6 x 6 m with 2 m aisles between plots. Plots were harvested 8 wk after seeding at ground level, chopped to a 5-mm particle size, and placed in mini-silos. The mini-silos (PVC pipes with rubber caps with capacity of 1.5 kg of green forage) were filled immediately after harvest.

➤Treatments were 3 levels of propionic acid, 0, 0.5, and 1.0% of the forage green weight distributed in a randomized complete block design with 5 replicates. Propionic acid was applied with a hand sprayer before ensiling. Silos were opened 12 wk after ensiling and analyzed for nutritive value, fermentation characteristics and bacterial relative abundance.

➤Forage samples were ground in an Udy mill (Udy Corporation, Fort Collins, CO.) to pass a 2-mm screen. Samples of the ensiled forage were analyzed for DM, CP, NDF, ADF, in vitro true digestibility (IVTD), NH₃-N, pH, VFA concentrations. and yeast and mold counts (AOAC, 2005). In addition, genomic DNA was extracted using the Mag-Bind® Universal Pathogen 96 Kit (Omega Bio-Tek, Norcross, GA) in accordance with manufacture instructions.

➤Data was analyzed using Proc Mixed procedure of SAS (SAS Inst. Inc., Cary, NC). The model included the fixed effect of treatment and the random effect of block. Orthogonal polynomial contrast was used to test treatment effects. The means reported were least square means and considered significant when $P < 0.05$.



RESULTS

- There was no effect of propionic acid levels on DM concentration ($P = 0.75$; Table 1), however, there was a linear increase in DM recovery with increasing levels of propionic acid ($P < 0.01$). In addition, increasing levels of propionic acid increased CP, and IVTD linearly, while decreasing NDF concentration ($P < 0.03$). There was no effect of propionic acid on ADF and NDFD concentrations ($P > 0.23$; Table 1).
- There was a linear decrease in pH ($P < 0.01$), acetic acid ($P = 0.02$), butyric acid ($P < 0.01$), isobutyric acid ($P = 0.01$), ammonia ($P < 0.01$), and yeast and mold count ($P < 0.03$) with increasing levels of propionic acid (Table 2). Conversely, lactic acid and propionic acid concentration increased ($P < 0.01$) with increasing levels of propionic acid (Table 2).
- Increasing propionic acid levels decreased the relative abundance of *Enterobacter* spp. (from 1.8 to 0.2%, $P = 0.03$, SE = 0.3) and *Clostridium* spp. (from 11.6 to 1.4%, $P = 0.02$, SE = 2.0), and increased the relative abundance of *Lactobacillus* spp. (from 0.6 to 6.7%, $P = 0.04$, SE = 0.2) and *Weissella* spp. (from 43 to 72%, $P < 0.01$, SE = 6.2)

Table 1. Nutritive value and DM recovery of sunn hemp silage treated with different levels of propionic acid.

Item	Propionic acid (%)			Contrast	SE
	0	0.5	1.0		
DM (%)	19	19	20	NS ¹	1.2
DM recovery (%)	96	98	98	Linear ²	0.5
CP, % DM	13.1	14.3	16.7	Linear	0.5
ADF, % DM	58.4	54.8	54.0	NS	1.7
NDF, % DM	66.6	63.2	61.7	Linear	1.7
IVTD, % DM	55	57	57	Linear	0.4
NDFD, % DM	47	48	49	NS	0.8

¹ NS = non significant² Linear = $P \leq 0.05$

Table 2. Fermentation characteristics of sunn hemp silage treated with different levels of propionic acid.

Item	Propionic acid (%)			Contrast	SE
	0	0.5	1.0		
pH	6.1	5.4	4.5	Linear ¹	0.3
Lactic acid, % DM	0.1	1.4	5.6	Linear	0.7
Acetic acid, % DM	4.5	2.4	2.1	Linear	0.4
Propionic acid, % DM	1.6	2.4	4.0	Linear	0.3
Butyric acid, % DM	4.5	3.9	0.4	Linear	0.9
Isobutyric acid, % DM	0.6	0.4	0.1	Linear	0.1
Ammonia, % CP	52	42	21	Linear	2.5
Yeast (log cfu/g)	2.0	1.5	0.6	Linear	0.1
Mold (log cfu/g)	1.8	1.0	0.8	Linear	0.2

¹Linear = $P \leq 0.05$

CONCLUSIONS

- Propionic acid treatment is an effective management practice to improve nutritive value and fermentation characteristics of sunn hemp silage.