

## BALING HIGH MOISTURE GUINEA GRASS HAY WITH PAPAYA SILAGE EFFLUENT

*Marcel M. C. Tsang, Erik R. Cleveland and Michael L. Christiansen. University of Hawaii at Hilo. College of Agriculture, Hilo, Hawaii 96720-4091 USA*

*Lalit R. Verma. Louisiana State University. Biological and Agricultural Engineering Department, Baton Rouge, Louisiana 70803-4505 USA*

### ABSTRACT

*Papaya silage effluent and urea were evaluated as preservatives for high-moisture guinea grass hay. The preservatives were sprayed into the hay as they were formed into round bales. When compared to untreated moist hay, papaya silage effluent treatment did not preserve hay quality in a 3-month storage period; urea treatment provided a small reduction in heating with a smaller increase in fiber-bound protein. However, when compared to untreated dry hay, preservative treated moist hay had much greater heating with higher heat-induced compositional losses (lower in vitro digestibility, greater fiber and fiber-bound protein) in storage. The moist hay was moldy and brown while the dry hay remained green and stable.*

KEYWORDS: *Hay, Guinea Grass, Preservative, Quality*

### INTRODUCTION

Losses in nutritional value of hay can be relatively high during curing and harvesting. Hay crop need to be dried to a relatively low moisture content (<20%) for stable storage. When extended periods of rain occurs during field curing, the entire crop may be lost. The longer the curing period in the field, the greater the risk of rain damage. Guinea grass (*Panicum maximum* Jacq.) is a low to medium quality forage crop that grows abundantly in Hawaii. Attempts by growers to harvest the crop at its optimum maturity for hay are very often unsuccessful because of the unpredictable weather pattern in the islands. Baling the hay at a higher moisture content (>20%) should reduce harvest losses. However, some type of treatment is required to inhibit microbial growth and deterioration of the wetter hay in storage.

Several substances have been used for preservation of moist bales in storage. These include organic acids (Sheaffer and Clark, 1975; Knapp et al., 1976; Nehrir et al., 1978; Khalilian et al., 1990; Rotz et al., 1991, Buckmaster and Heinrichs, 1993), anhydrous ammonia (Koegel et al., 1983; Rotz et al., 1986), urea (Ghate et al., 1981; Rotz et al., 1990; Riet et al.,

1988) and microbial inoculants (Rotz et al., 1988; Nelson et al., 1989; Nelson et al., 1989, Tsang et al., 1989). Propionic acid treatment to reduce storage loss in high moisture hay (>20%) has shown mixed results. Sheaffer and Clark (1975); and Knapp et al., (1976) reported reduced molding, heating and storage losses in moist hay treated with propionic acid over untreated hay of similar moisture content. Davies and Warboys (1978) found reduced heating in grass treated with propionic acid. However there was little effect on storage loss and forage quality following storage. Rotz et al., (1991) found that propionic acid treatment provided a reduction in heating and dry matter loss in alfalfa hay during the first month of storage when compared to untreated moist hay. However, storage losses of treated and untreated hay were similar after a six-month storage period, and acid-treated damp hay was generally lower in quality, poorer in color and moldy when compared to untreated dry hay. Ghate et al. (1981) reported that hay, of 21% to 28% moisture, treated with urea solution at a rate of 6.5% of hay dry matter heated less, developed less mold, and maintained a better color than untreated hay. Riet et al. (1988) found an increase in crude protein contents in ryegrass bales treated with granular urea at baling. However, urea application did not result in greater digestibility and extensive fungal growth was observed in the bales after 60 days storage. Rotz et al. (1990) also found an increase in crude protein concentrations in alfalfa hay treated with granular or powdered urea at baling. However, when compared to untreated dry hay, urea-treated high moisture hay were of lower quality and had higher losses following storage.

Nelson et al. (1989) inoculated large round bales of alfalfa at 64.3, 73.4 and 84.7 dry matter content with a lactic acid producing bacterial inoculant. They reported that inoculation appeared to aid in the preservation of alfalfa forage quality at 73.4% dry matter but provided no benefit at 64.3 or 84.7% dry matter. In a similar study, Nelson et al. (1989) baled alfalfa at 56.6 and 73.5% dry matter with 0.1% (wet weight) silage inoculant into small rectangular bales. In contrast to their previous study with large round bales, inoculation appeared to be most beneficial for low dry matter content alfalfa when baled into small rectangular bales. The 56.6% dry matter alfalfa exhibited decreased stack temperature and lower heat-induced loss in hay quality in storage. Tsang et al. (1989) reported no significant benefit in high moisture guinea grass hay inoculated with a lactic acid producing bacteria.

Organic acids and ammonia based compounds appear to have some potential for preserving high moisture hay. A study was designed to investigate the use of papaya silage effluent and urea solution as preservers for high moisture guinea grass hay. The hypothesis was that urea solution, and the acidity and naturally occurring organisms in the silage effluent may prevent or reduce spoilage of the damp hay during storage. Papaya fruit is readily available in the State of Hawaii and should provide a cheap source for a hay preserver if successful results are obtained. The objective of the study was to evaluate changes in quality of high moisture guinea grass hay treated with urea solution and papaya silage effluent at baling.

## PROCEDURE

**Papaya Silage Effluent.** Ripe papaya fruits were chopped by hand into small pieces (<2.5 cm) and tightly packed into five-gallon plastic containers. A heavy circular metal plate was used to compress the cut materials in the containers. The containers were then sealed and the fruits

allowed to ensile for about a week. A bunsen valve (Tilley and Terry, 1963), placed on the cover of each container, was used as a gas release valve. The valve allowed silage gas to escape but did not allow air in. At the end of the ensiling period, the containers were emptied. The ensiled papaya was diluted with water (50% by volume) and the mixture filtered several times through a set of fine screen mesh sieves to recover the effluent. The effluent was stored in one-gallon size plastic containers in a refrigerator at 0 °C until it was used. The pH of the effluent was taken and the average pH was about 3.85.

**Field Test.** Field trials were conducted in late September on a hay farm in Kau on the island of Hawaii. Guinea grass, at the pre-bloom stage of maturity, was harvested with a mower conditioner and allowed to dry in the field until it was ready to be baled. Treatments included baling the hay at greater than 30% moisture with and without a preserver, and at less than 20% moisture without a preserver. The hay was formed into round bales (227 kg) using a Heston (model 550) round baler. Preservative treatments included papaya silage effluent and a 20% urea solution (w/v). The preservatives were applied using two spray nozzles (Teejet 8008) mounted on a boom placed over the hay pick-up conveyor and just prior to entering the baling chamber. Nozzle size was selected to prevent clogging during operation. The sprayer pump was powered by a 12-volt direct current motor connected to the tractor battery and activated by the operator in the tractor cabin. The preservative solution was applied at about 37 kg/t of hay. The sprayer tank was rinsed and the nozzles ran for a short period of time when the solution was changed. A total of six bales were harvested per treatment.

Immediately after baling, each bale was tagged and its temperature measured using a bimetallic (0.06 X 61 cm stem) thermometer. The bales were then stored under a well-ventilated barn. Measures of hay quality were storage temperature, crude protein (CP), acid detergent insoluble crude protein (ADIP; an estimate of fiber bound protein), acid detergent fiber (ADF) and *in vitro* dry matter digestibility (IVDMD). Bale temperatures were taken daily until hay temperature returned to ambient. Samples for chemical analysis were taken with a core sampler immediately after baling, after 21 days, and after 3 months of storage. The samples were dried at 60 °C for 72 hours and then ground in a Wiley mill through a 1 mm screen. The CP and ADF concentrations (dry weight basis) were determined by standard laboratory procedures (AOAC, 1960). The ADIP was determined by the method described by Goering and Van Soest (1970), while the procedure outlined by Nelson and Montgomery (1975) was used for IVDMD.

The experimental design was completely randomized and means were separated using Fisher's protected least significant difference (LSD) test.

## RESULTS AND DISCUSSION

**Bale Temperature.** Temperature profiles of the bales during storage are shown in Figure 1. Baling the moist hay with the preservers did not appear to significantly reduce heating during storage. Both the untreated and treated moist hay heated considerably during storage. Bale temperature reached a maximum between 8 to 14 days in storage. Peak temperatures in the moist bales was about 60 °C in both the untreated bales and those sprayed with the papaya silage effluent. The temperatures then declined steadily for the rest of the storage period, probably due

to the gradual drying of the bales which affected the growth of heat causing organisms, but remained above ambient for a relatively long time period (Figure 1.). The average moisture content was about 26% and 14% in the moist and dry hay, respectively, after 21 days in storage. Urea treatment provided a small reduction in the heating of the moist hay when compared to the untreated hay, but the urea-treated hay heated much more than the dry hay. Rotz et al. (1990) reported a similar trend in rectangular alfalfa hay bales (> 25% moisture) treated with urea. The dry bales remained near ambient temperature for the whole storage period. The amount of heat developed in stored agricultural products is generally an indicator of the quality of the product during storage. From the temperature data, both urea and papaya silage effluent were not effective in preventing heating of the moist hay in storage.

**Hay Quality.** The summarized results of the chemical analysis are presented in Table 1. The preservative treated hay did not prevent or reduce storage loss. As indicated by the temperature data, substantial losses in quality occurred in both the treated and untreated moist hay. Although the urea-treated hay heated less, in general, there was no difference in hay quality between the urea and papaya effluent treatments. When compared to the initial period and the dry hay, the moist hay showed substantial reduction in IVDMD with a corresponding increase in fiber components (ADF) during storage ( $p < 0.05$ ). Perhaps the moisture content at baling was too high, especially in the fleshy stems which will typically be much wetter than the average moisture for the hay, or the application rate too low for the preservative to show any effectiveness. The dry hay remained in fairly good condition with only a small reduction in quality. However, there was no difference or reduction in crude protein concentration among treatments. Application of urea to the hay did not increase the total nitrogen (crude protein) concentration of the hay as would be expected from the addition of nonprotein nitrogen from the urea. In several studies, an increase in total nitrogen concentration of hay treated with urea has been reported (Rotz et al., 1990; Riet et al., 1988). Very low nitrogen retention from the urea may indicate loss of urea solution to the ground during application with only a small quantity actually retained in the bales or loss in storage by the volatilization of ammonia created by the conversion of urea.

Although crude protein content of forages is generally recognized as one of the main indicator of forage quality for ruminants, the amount of protein that is available to the animal is a more accurate indicator of quality in stored hay. A decrease in protein availability and digestibility is often associated with heating of forage during storage. An increase in bound protein resulted from heating in the moist hay (all treatments) when compared to the dry hay ( $p < 0.05$ ). However, among the moist bales, treatment with urea resulted in a smaller reduction in available protein during storage ( $p < 0.05$ ). These observations are in agreement with the heating profile in the bales (Figure 1). An increase in bound protein, accompanied by a slight decrease in IVDMD, was also observed in the dry hay after 3 months in storage. Extensive fungal growth was observed in the moist hay irrespective of treatment. Although the urea-treated hay appeared slightly better in color than the untreated or papaya effluent treatment, the appearance was not comparable to that of untreated dry hay. The moist hay was brown in color after storage while the dry hay stayed green.

## CONCLUSIONS

Moist Guinea grass (>30% moisture content) hay heated in storage while dry hay remained near ambient temperature. Heat induced compositional changes (increased ADF, reduced IVDMD and increased ADIP) were more severe in the moist hay. Papaya silage effluent was not effective in preserving moist hay in storage. Urea treatment of high moisture hay provided a small improvement in preservation when compared to untreated hay of similar moisture content. The improvements included a small decrease in heating during storage and a lower reduction in bound protein (ADIP). However, no increase in crude protein concentration from addition of nonprotein nitrogen to the hay was observed. When compared to untreated dry hay, the heating and quality loss were higher. Moist hays were brown in color after storage while dry hay remained green. Dry hay remained fairly stable in storage with only a small loss in quality after a 3-month period.

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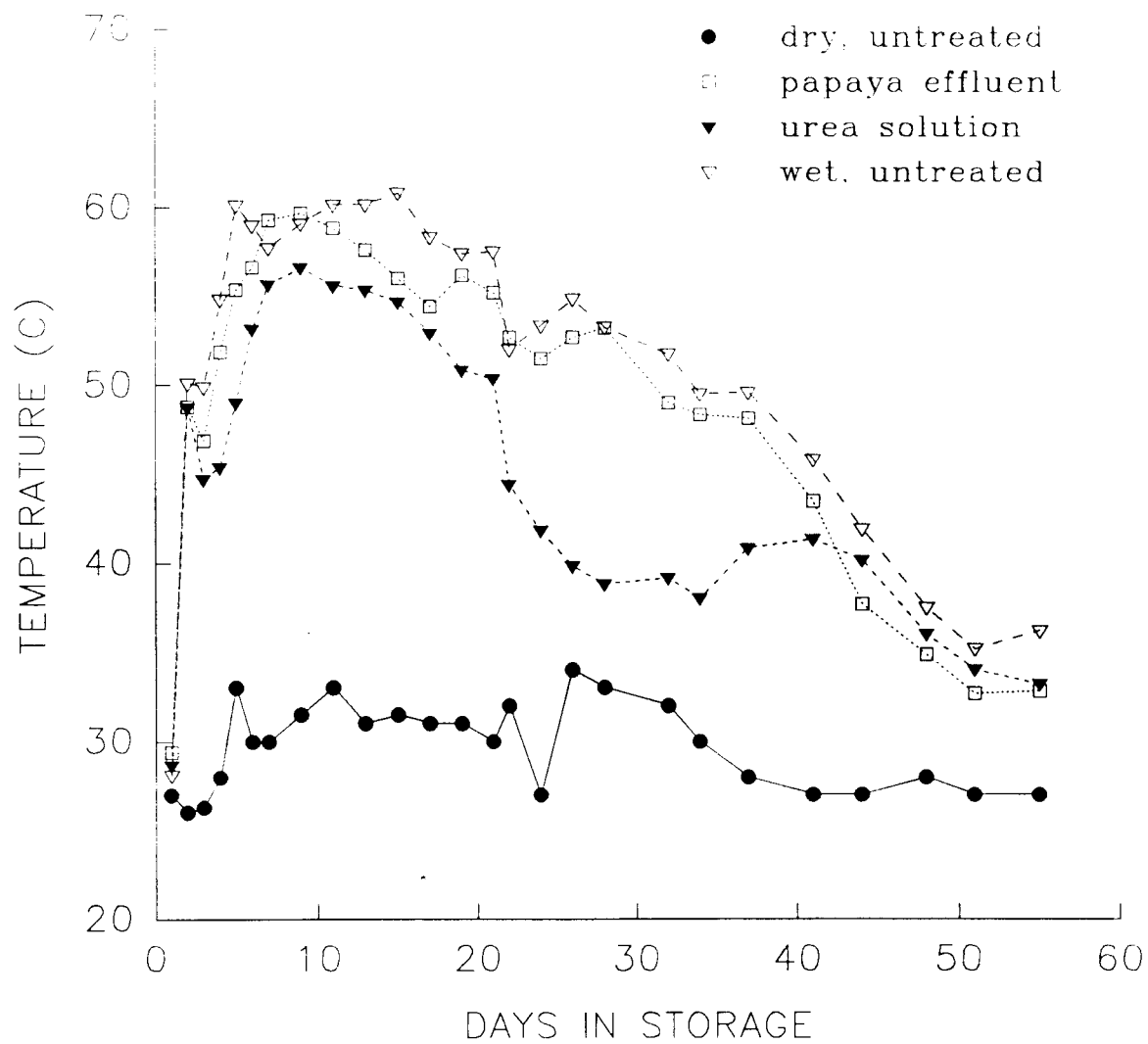


Figure 1. Temperature Profiles in Guinea Grass Bales During Storage.

TABLE 1. Chemical estimates of quality of guinea grass bales during storage.

Treatments	Initial Moisture % w. b	Quality From Storage (% Dry Matter)*											
		Initial Period			21 Day Storage			3 Months Storage					
		CP	ADIP	ADF	IVDM	CP	ADIP	ADF	IVDM	CP	ADIP	ADF	IVDM
Untreated (dry)	15.3	8.51	1.39	41.3	56.1	9.02	1.40 c	41.7 b	56.7 b	9.40	1.59 c	43.2 b	54.9 a
Untreated (wet)	33.4	8.98	1.53	41.2	56.3	8.74	2.07 a	45.2 a	53.3 a	9.36	2.69 a	49.3 a	50.0 b
Papaya Effluent	34.8	9.63	1.55	43.1	55.1	9.62	2.12 a	46.3 a	52.5 a	9.75	2.74 a	49.8 a	49.7 b
Urea Solution	31.8	9.42	1.56	44.4	53.9	9.71	1.91 b	46.9 a	52.1 a	9.57	2.36 b	50.1 a	49.5 b

\* CP = crude protein; ADIP = acid detergent insoluble protein; ADF = acid detergent fiber  
 IVDM = invitro dry matter digestibility  
 abc = values followed by the same letters are not significantly different by LSD test (p<0.05)