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Effect of Different Processing Methods on the Quality of Alfalfa Hay

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Abstract: Experiments were conducted to investigate the problems of severe nutrient loss of traditional alfalfa hay processing methods and storage difficulties in moist or rainy conditions. Alfalfa hay was treated with different processing methods, non-processing was taken as Control (CK). Bale treatments were sampled before storage and at 0, 30, 60, 90 and 120 days post baling. Nutrient content and the curve of nutrient change during 60 days storage were analyzed to study the effect of compound additives on the nutrient quality of alfalfa hay baled under high-moisture content.

Key words: Alfalfa hay, processing methods, nutrient quality, shade, CK

INTRODUCTION

Alfalfa hay is one of the best fodder in the modern animal husbandry industry. However, loss from dry matter and quality during harvest and storage are very great in most countries (Knapp *et al*., 1975; Rotz and Abrams, 1988). Typical dry matter losses for the full process are 15-25% (Table 1) for hay made under good drying conditions and 35-100% for hay damaged by rain (Harris *et al*., 1974; Brandt *et al*., 1984; Lines *et al*., 1996; Hundtoft, 1965). And alfalfa leaves which are highest in nutritive value to livestock are most susceptible to loss resulting in an overall reduction of crop quality. Leaves of alfalfa hay that contain low moisture fall off in great numbers during the process of field curing, baling, transportation and storage (Johnson *et al*., 1984; Wilkinson, 1981; Collins, 1983). Baling alfalfa hay at moisture concentrations above 200 g kg^{-1} can cause negative quality changes via spontaneous heating within the hay mass, Maillard reactions and increased concentrations of field and storage fungi (Robert, 1995). Spontaneous heating and associated loss of energy occur due to respiration by both plant enzymes and a variety of microorganisms associated with the hay. In moist hays (>200 g kg^{-1}), microbial respiration, primarily via oxidation of nonstructural carbohydrates can cause substantially elevated temperatures (>50°C) in the hay mass (Rotz and Muck, 1994). Microbial populations are sensitive to both temperature and moisture content, substantial changes in these populations are known to occur in response to temperature changes and the dissipation of water from the hay (Robert *et al*., 1987). This not only causes more severe nutrition loss but also reduces digestibility and palatability significantly (Brandt *et al*., 1984). Typically, these complex processes gradually reduce the moisture content of the hay to <180 g kg^{-1} after 30 days in storage, thereby limiting microbial activity and establishing relatively stable conditions in the hay mass (Rotz and Muck, 1994).

Table 1: Typical losses of forage-handling systems

Moisture content when mowed	Field loss (%)	Storage loss (%)	Total loss (%)
Heat-cured dry	12-18	3-4	15-22
Field-cured dry (40% moisture)	12-18	4-6	16-24
Field-cured dry (20% moisture)	15-22	2-4	17-26

Van Soest and Robertson (1991)

Xiahe country, located in the northeastern margin of the Qinghai-Tibet Plateau is one of the major livestock husbandry counties in Gansu Province. The alfalfa harvest time of this area is mainly in the rainy season becase of the special geographical environment and

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climate characteristics. This basic reality means that it's difficult to obtain high quality alfalfa hay by using traditional methods in this area. Alfalfa hay treated with additives and baled at a high-moisture level could tolerate the severe losses caused by both serious falling off of leaves and mildewing. However, all additives will increasing the processing cost and forage safety risk of alfalfa hay. Processing with special technology is the most safe, economical and effective method to avoid a great loss of nutrition have great practical significance for efficiency and quality improvement in forage processing and animal feeding.

MATERIALS AND METHODS

Experimental site: The experiments were conducted during 2012 to 2013 at Xiahe County, Gannan area and Gansu Agricultural University. Studies included nutritional change of alfalfa hay treated with different additives during 120 days storage. The alfalfa used in the experiment was first-cut Golden Empress alfalfa planted at the experimental field of Yongjie livestock Co., Ltd. Gannan Farm (Gansu Province) in 2012. It was mainly in the early flowering stage when harvested.

Experimental procedure: This experiment took crushed curing (T1), hayrack curing (T2), crushed and chopped the grass into 25 cm length (T3), chop the grass into 25 cm length to curing (T4) and dry in the shade (T5) as the treatments. Air-curing drying was used for control treatments (CK). Alfalfa hay was baled at the moisture concentrations of 18~20%. All treatments were replicated three times in this experiment. During the 120 days storage process, triplicate samples were collected, respectively on days 0, 30, 60, 90 and 120 (Table 2).

Chemical analyses: After drying and grinding, forage samples were analyzed for Dry Matter (DM), Crude Protein (CP), Neutral-Detergent Fiber (NDF), Acid-Detergent Fiber (ADF), Ether Extract (EE). The amount of CP was determined using the DigiPREP TKN Systems (BUCHI_339). The alfalfa hay was analyzed for DM (method 930.15) according to AOAC. The NDF and ADF, both inclusive of residual ash were determined according to Van Soest *et al*. (1991) and Robertson. The amount of EE was determined using the Soxhlet Extractor Method.

Statistical analyses: The linear relationships between nutrient content and storage were analyzed using the Statistical Product and Service Solutions (SPSS) Statistical Package (Version 16.0 for Windows). All data in this study were tested at significance levels of $p<0.05$ and $p<0.01$ by one-way ANOVA. Differences among treatment means were tested with the Duncan multiple range test considered significant if the $p\leq0.05$ and $p\leq0.01$.

RESULTS

The moisture content of T1 to T5 decreased to 16.3-16.8%, respectively, in the 1st 30 days immediately after baling (Fig. 1). In contrast to the special curing treatment results, the moisture content of CK decreased slowly both at the very beginning and at the latter part of the storage process. Finally, the moisture content of T1 and T2 had decreased to 12 and 11.9% after 120 days of storage. There was no discernible difference in corresponding moisture-reducing coefficients between all curing process methods.

The CP content of T1 and CK was the lowest of all treatments because of severe losses during the process of field curing, baling, transportation and the 120 days storage process (Fig. 2). The CP content of T1 and CK, the T2 reduced dramatically from 16.8-14.5% in the 1st 30 days because of the losses caused by spontaneous heating and microbial build up. CP contents of alfalfa

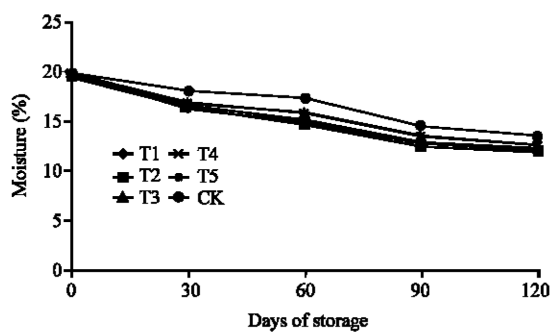

Fig. 1: Change of moisture content of different treatments during 120 days storage process

Table 2: Processing methods and detail

Processing methods	Operational approach	Introduction
Air-curing drying (CK)	Natural air drying	Good ventilation
Crushed curing (T1)	Drying after mechanical flattening	The stalk visible cracks but not disconnect
Hayrack curing (T2)	Drying on a hayrack	Good ventilation
Crushed and chopped length (T3)	Crushed after chopping the grass into 25 cm length	-
Chopped length curing (T4)	Chop the grass into 25 cm length	-
Dry in the shade (T5)	Drying in the shade after harvest	-

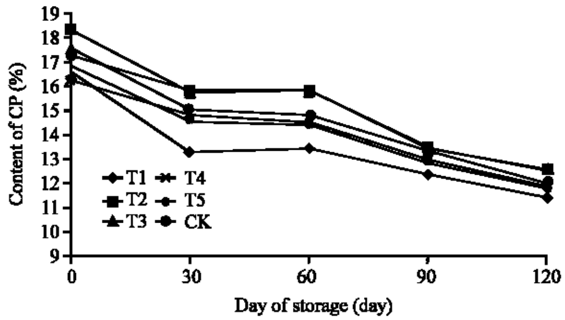

Fig. 2: Change of CP content of different treatments during 120 days storage process

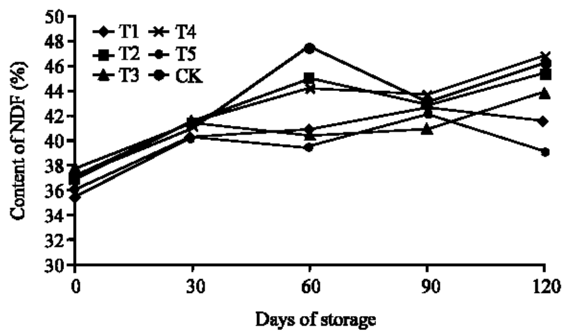

Fig. 3: Change of NDF content of different treatments during 120 days storage process

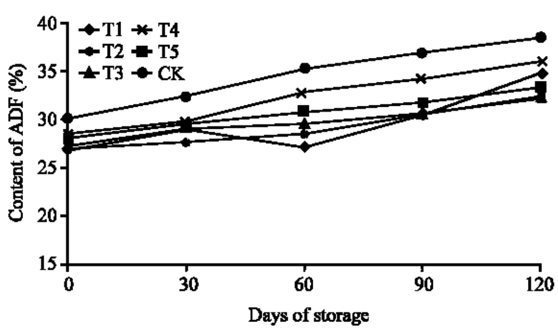

Fig. 4: Change of ADF content of different treatments during 120 days storage process

hay processed with improved processing methods (T3, T4) were obviously higher than others at the end of the storage process.

The changes of NDF and ADF content are shown in Fig. 3 and 4. The fiber content of CK was obviously higher than that of other groups at the very beginning of the storage period, the reason is that the stems made up a high percentage due to leaf drop. There was an increase in ADF content because of the severe nutrient oxidation and degradation. Finally, the percentage of ADF reached 35.9% after 120 days storage. Fiber contents of T2, T3 and T5 increased more slowly. There was no significant change in EE content of curing treatments during the entire storage process (Fig. 5). The EE content of CK and T4 had two obvious fluctuations because of spontaneous heating and microbial built up. It decreased significantly and achieved peak maximum in the 1st 60 days. The minimum value of Ck and T4 had dropped to 1.7 and 2.3% by 120 days. The EE content of CK and T2 were the lowest of all treatments and dropped to 1.7 and 1.8%. There was a gradual decline from 60-120 days.

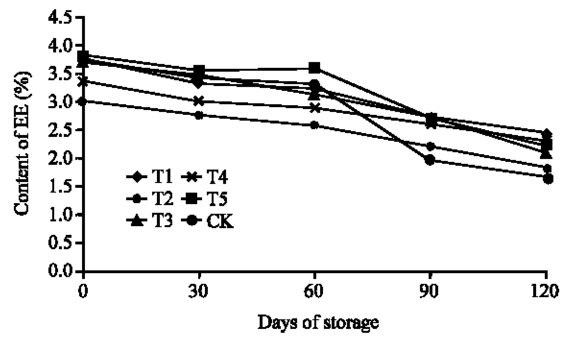

Fig. 5: Change of EE content of deferent treatments during 120 days storage process

Table 3: Nutrient contents of alfalfa hay with different treatments after 120 days storage process

	(DM %)			
Treatments	CP	NDF	ADF	EE
CK	11.99^{bB}	46.24^{aA}	38.30^{aA}	1.67^{dD}
T1	11.41^{cC}	41.58^{cC}	34.69^{bB}	2.45^{aA}
T2	11.77^{bB}	39.18^{dD}	32.32^{cC}	1.82^{dD}
T3	12.53^{aA}	43.93^{bB}	32.24^{cC}	2.11^{cC}
T4	12.14^{bB}	46.76^{aA}	35.87^{bB}	2.30^{bB}
T5	12.58^{aA}	45.44^{aA}	33.20^{cC}	2.21^{bB}

$^{a-c}$Values in the same column with differences are significantly different at $p<0.05$; $^{A-C}$Values in the same column with differences are significantly different at $p<0.01$

Nutrient contents at the end of the 120 days storage period of different treatments are shown in Table 3. The CP and EE contents of CK and T2 were the lowest of all because of the serious loss caused by leaf drop. Nutrients of T4 and T1 were distinctly reduced by spontaneous heating and microbial build up. The CP and EE were decomposed by microorganism and the percentages of fiber increased.

DISCUSSION

This experiment shows that the nutrient-component portion of alfalfa hay without curing treatments declined over in the 120 days storage period. The CP content and EE content of the CK were lower than that of other treatments because of the loss due to the shedding of leaves. Although, the nutrient content of T4 and T1 were higher than the CK at the very beginning of the experiment, it decreased rapidly during the 120 days storage period with the spontaneous heating, microbial bulid up and respiration. Many studies show that changes of alfalfa hay with high-moisture content in the preservation process were the most significant of all.

Nutrient contents of alfalfa hay baled at suitable moisture content and with low loss of leaves were significantly higher than that of hay baled at low-moisture content. Further, the nutrient loss of alfalfa hay treated with special curing treatments was obviously less than that of the CK during the storage process. The results prove that improved curing treatments can address the contradiction of nutrient loss and mustiness caused by different moisture contents. Compared with the other treatments, the CP content of the T3 and T5 was slightly higher while the fiber content were lower. Nutrients of alfalfa hay processed with special curing were much higher than those of the control treatments and the difference was very significant.

Two of the most important factors that favour build up of microbials are appropriate temperature and high moisture content. Moisture is an essential factor. High-moisture treatment combinations that favor extended microbial activity continued to depress forage quality. Curing Treatments (T3 and T5) that can rapidly reduce the moisture content of alfalfa hay during the storage stage immediately after baling are best. Decrease of moisture content and consumption of oxygen did not favour of the survival environment for the microbials and reduced the probability of rotting in the alfalfa hay. These effects can also reduce the losses caused by respiration freshly harvest alfalfa. All evidence suggests that special curing treatments had positive effects on reducing severe losses during the processing link and reducing mildewing in the storage process.

The nutritional value of fodder has vital significance for livestock. It provides energy, participates in the body's metabolism and is also involved in the composition of meat, milk, skin, hair, bone and other tissue organs directly. This means that the quality and economic value of alfalfa hay to a great extent, depends on different proportions of nutrients (Wittenberg and Moshtaghi-Nia, 1990). A great deal of experiments and research shows that the levels of moisture content and processing technology have a very serious influence on the nutrient contents of alfalfa hay. Proper drying before baling is an effective method to reduce the severe nutrient loss caused by leaf drop and the mildewing processes of alfalfa hay during storage. Better processing and drying before baling and storage also could improvied the quality and economic value of alfalfa hay via increasing the proportion of protein and other nutrients.

CONCLUSION

The results showed that the nutrient-component proportion of conventional alfalfa hay changed considerably during the 120 days storage process. Nutrient content of alfalfa hay processed with better curing treatments (T1, T4) retained its value to be accuracy after preservation for 120 days. The water content of hayrack curing (T2) was 1.6% points less than that of CK. Crude protein of crushed and chopped into 25 cm length (T3) and dried in shade (T5) were increased by 0.5 and 0.6%, respectively while NDF and ADF of T3 decreased by 2.3 and 6.1%. Experiments show that T2 is an effective method to reduce the severe nutrient loss caused by leaf drop and mildewing. Improved with special curing treatments can ensure higher quality alfalfa hay.

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