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Original Article

Physical characteristics, nutrient composition, and digestibility Kudzu haylage treated with various additives for ruminant

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Abstract

Objective: This study aimed to evaluate the physical characteristics, nutrient composition and digestibility of Kudzu haylage that was treated with additives of rice bran, pollard, palm kernel and molasses.
Methods: The study was performed into a completely randomized design with 5 treatments and 5 replications. The treatments were control: Kudzu haylage without additive (P0), Kudzu haylage and 5% rice bran (P1); Kudzu haylage and 5% pollard; Kudzu haylage and 5% palm kernel; Kudzu haylage and 5% molasses. The data were analyzed by Analysis of Variance, mean comparisons by the Tukey test were performed using R x64 4.1.0.
Results: The results showed that in the haylage making process, all additives improve Kudzu haylage physical characteristics, nutrient composition, and digestibility. Kudzu haylage with molasses addition resulted brownish yellow color, soft crumble texture, sour smell with 2.4% spoilage on haylage surface. The Fleigh value, nutrient composition and digestibility were increased with molasses addition.
Conclusions: Based on the physical characteristic, nutrient composition and digestibility of Kudzu could be preserved as haylage with additives of rice bran, pollard, palm kernel and molasses. The best treatment on Kudzu haylage was 5% molasses addition that improved physical characteristics, nutrient composition, and digestibility.

Keywords: Fleigh value; Haylage; Kudzu; Preservation; Quality

INTRODUCTION

Forage availability is fluctuating due to the change of land use [1] and season [2]. In the rainy season forage production is plentiful then the availability decreases in the dry season [3]. Hence, to fill this gap, integrated farming with plantation can be a good option to utilize cover crop as forage [4].

Kudzu (*Pueraria montana* (Lour.) Merr) was introduced to Indonesia as cover crop in rubber and palm plantation [5]. Kudzu is a perennial semi-woody plant, trailing to high-climbing, twining vine that native to eastern

India, China and Japan [6]. Kudzu could be grown in a wide range of soil types including sandy soils, acid soils, lime soils, lowlands with high water tables, in over-heavy subsoil and can endure drought and high temperatures [7]. Kudzu has been reported by Mannetje and Jones [8] to have 125–250 g/kg dry matter (DM) of crude protein (CP) concentration, 300–400 g/kg DM of crude fibre (CF) concentration, 1.5–4.5 g/kg DM of phosphor, and 4–16 g/kg DM of calcium. According to Chen *et al.* [9], Kudzu has high lactate buffering capacity (LBC), more than 4.8 and low water-soluble carbohydrate. Kudzu contains 53–66% carbohydrate and is mostly in the form of starch [10] with only 1.2–9.0% soluble carbohydrates [11].

The high production of kudzu in the plantation area has to be transported and distributed to the ruminant farmer area. Therefore, the forage preservation technology is needed to prolong the forage quality and palatability [12]. The main methods of forage conservation are hay, silage, and haylage [13]. Hay making in the rainy season would face a problem on foliage drying due to the high precipitation per day [14]. Haylage making is one alternative method in forage conservation that adopted the form of hay making (wilting and baling) and silage (anaerobic fermentation) [12]. Elizalde and Henríquez [15] reported that haylage increased dry matter intake due to chemical composition and feeding behavior changes.

This study aimed to evaluate the physical characteristics, nutrient composition and digestibility of Kudzu haylage that was treated with additives of rice bran, pollard, palm kernel and molasses.

MATERIALS AND METHODS

Research site

The research was conducted from December 2021 to April 2022 at the Faculty of Animal Sciences, IPB University, Bogor, Indonesia.

Research design and treatments

The kudzu haylage was made using four types of additives, i.e. rice bran, pollard, palm kernel and molasses (Table 1). The haylage was allocated in complete randomized design with 5 treatments and 5 replicates. The treatments were control: kudzu haylage without additive (P0), kudzu haylage and 5% rice bran (P1); kudzu haylage and 5% pollard (P2); kudzu haylage and 5% palm kernel (P3); kudzu haylage and 5% molasses (P4). The foliage water was adjusted through sun dried and the additives percentage calculated based on as fed. A total of 25 plastic buckets with 2 kg materials in each were prepared and only opened 21 days after ensilage.

Haylage making

Kudzu foliage was harvested from kudzu garden in the second establishment year. Kudzu foliage was cut from 6 months old plants at 10 cm above ground level, chopped immediately into small pieces of 4 - 8 cm using a chopper machine. The foliage was sun dried in three days to reduce the moisture content to 40 to 60% [12]. The foliage was packed in plastic bags and compacted in 2- layer plastic bags. Each bag contained 2 kg then it was bound by rubber band and stored in shade under a roof with temperature 29 to 32°C.

Sample analyses

Haylage samples were analyzed for physical characteristics and nutrient content after 21 days of ensilage. The physical characteristics included color, texture, smell, and presence of fungus based on Department of Agriculture criteria [16] were evaluated by 5 experienced panelists. All air-dried plant samples were dried in a forced-air oven at 60°C for 48 h, and ground to pass through a 1 mm sieve for chemical analyses. Haylage extract pH was determined by grinding 20 g of samples and adding 100 mL of water then pH was immediately measured using a pH meter. The following analyses were nutrient content using AOAC procedures [17]. The organic and dry matter digestibility were determined by two-stage in-vitro technique [18].

Fleigh's value calculation

The quality of haylage was assessed by the index of Fleigh's value which was calculated by means of pH values and dry matter percentage (DM) of haylage using the equation [19]:

Fleigh's value= 220+(2×%DM−15)−(40×pH) ...(1)

According to the index, haylage was considered to be very good when it had score between 81 and 100; to be good with a score between 61 and 80; to be medium with a score between 41 and 60; to be bad with a score between 21 and 40 and to be very bad when it had score of <20.

Data analysis

The data were analyzed statistically with R x64 4.1.0 using Analysis of Variance Test (ANOVA), then mean comparisons by the Tukey test [20]. The analyses used several packages i.e. Rcmdr, Agricolae, car, and lsmeans.

RESULTS

Nutrient composition of kudzu foliage

The nutrient composition of kudzu foliage is shown in Table 1 revealed that dry matter and protein content was 16.40%±0.05% and 15.99%±6.09%, respectively. Nutrient composition indicates that kudzu foliage has substantial potential as a ruminant feedstock, despite the high content of crude fiber (66.68%±18.77%).

Physical quality

The kudzu haylage color was different with each additive (Table 2), there were brownish yellow (P0, P2, P4) and yellowish brown (P1, P3). The haylage texture in all treatments were quite similar to crumble resulting from the chopping process and kudzu characteristic after drying stage. There were some molds in all haylage treatments at 21 days after ensilage, including the treatment with molasses additives that had thin layers on the top of haylage products. On the other hand, haylage without additives showed badly preserved haylage with the appearance of the largest mold in the top of the haylage bag without additive treatment (P0).

Nutrient composition of Kudzu haylage

The haylage acidity (pH) was significantly decreased with all the additive treatments ($p<0.001$). These results were comparable with the physical characteristic (Table 1), respectively, which was presented with the sour smell on the additive treatments. The mean haylage pH value was lowest in the 5% molasses treatments (4.72±0.12), while the nutrient composition varied on each treatment. In these haylage, pH values declined below 5 led to the better fermentation properties.

Table 1. Nutrients composition of haylage ingredients

Nutrients	Fresh Kudzu foliage	Rice bran[23]	Pollard[25]	Palm Kernel[26]	Molasses[28]
DM (%)	16.40±0.05	88.72	89.66	91.41	65.33
Ash (%)	6.73±0.84	10.44	3.49	4.69	nd
Extract ether (%)	14.06±1.26	18.47	5.18	0.25	nd
Crude protein (%)	15.99±6.09	8.43	15.15	16.95	8.30
Crude fiber (%)	66.68±18.77	22.17	7.08	13.46	nd
WSC (%)	1.2-9.0[11]	15.00[24]	12.52	3.07-8.73[27]	52.78

DM: Dry matter; [11]Sage *et al.*; [23]Azizah *et al.*; [24]Chandi and Sogi 2007; [26]Sathitkowitchai *et al.* 2018; [27]Bello *et al.*; [28]Hiep *et al.* 2008.

Table 2. Physical characteristic of kudzu haylage with different additives

Treatments	Color	Texture	Smell	Spoilage
P0	Yellowish brown	Crumble, slightly moist	Slightly sour	12,53%
P1	Yellowish brown	Crumble	Sour	4,12%
P2	Brownish yellow	Crumble	Sour	4,17%
P3	Yellowish brown	Crumble	Sour	5,4%
P4	Brownish yellow	Soft crumble	Sour	2,4%

Kudzu haylage without additive (P0), kudzu haylage and 5% rice bran (P1); kudzu haylage and 5% pollard (P2); kudzu haylage and 5% palm kernel (P3); kudzu haylage and 5% molasses (P4).

Table 3. Effect of different additives on nutrient composition of kudzu haylage

Parameter	Treatments				
	P0	P1	P2	P3	P4
pH	5.68±0.30^{c}	5.32±0.07^{bc}	5.06±0.06^{b}	5.11±0.06^{b}	4.72±0.12^{a}
DM (%)	43.77	50.10	44.65	52.49	42.81
Ash (%)	7.33	8.46	7.70	7.50	7.89
Extract ether (%)	12.00	13.38	6.07	9.39	12.83
Crude protein (%)	15.53	15.94	17.06	17.32	16.45
Crude fiber (%)	68.85	61.73	68.62	65.15	47.31

Kudzu haylage without additive (P0), kudzu haylage and 5% rice bran (P1); kudzu haylage and 5% pollard (P2); kudzu haylage and 5% palm kernel (P3); kudzu haylage and 5% molasses (P4); DM: Dry Matter; pH means with different superscripts differ significantly ($p<0.05$).

Table 4. Effect of different additive on Fleigh value and digestibility of Kudzu haylage

Parameter	Treatments				
	P0	P1	P2	P3	P4
Fleigh value	65,34	92,40	91,90	>100	>100
Dry matter digestibility (%)	35,86	36,55	40,81	42,93	47,04
Organic matter digestibility (%)	32,53	33,44	37,91	39,47	44,49

Kudzu haylage without additive (P0), Kudzu haylage and 5% rice bran (P1); Kudzu haylage and 5% pollard (P2); Kudzu haylage and 5% palm kernel (P3); Kudzu haylage and 5% molasses (P4).

Fleigh value and digestibility of kudzu haylage

The data shown in Table 4. emerged that all produced haylage with additives showed the higher Fleigh value, dry and organic matter digestibility than without additives. The addition of palm kernel and molasses produced the highest quality haylage (>100 Fleigh value). Followed by, haylage of the treatments pollard and rice bran that showed satisfactory preservation (good silages). All additives increased the dry and organic matter digestibility.

DISCUSSION

The crude protein of kudzu foliage in this research was quite low with high variance between replicates (15.99%±6.09%) than previous research that reach 19.1%-24.1% [6, 21]. The high variance of crude protein occurs due to the high differences' nutrient in plant parts, especially between leaf and stem [22]. The result also related with the high content of crude fiber that twice than the other research [6]. The low crude protein and high crude fiber related with the late harvest time (in 6 months after the last harvest) and the lack of fertilizer addition [29]. Moreover, the proximate analysis was conducted for the whole fraction, i.e. leaf and stem parts that contained high crude fiber [6]. Corley *et al.* [30] reported that each part of kudzu foliage contained different crude protein percentage and the higher percentage located on leaf. However, the harvest leaf only resulted in low herbage biomass and separating the leaf from the whole plant fraction was not practical [21].

Kudzu haylage was acceptable in the evaluation of color, texture, smell and spoilage. The texture of haylage without additives was slightly moist, less sour and contained more molds on the haylage surface. The different additives that have effect on the ensilage process were shown on spoilage percentage related to low WSC content in Kudzu [11]. Kudzu haylage needed high WSC additives content to support microbial growth in the ensilage process. Among the additives, the highest WSC content was molasses more than 50% [28], followed with palm kernel up 18% [27], pollard around 12.52% [25] and rice bran 5.42% [24]. These WSC content affected spoilage level, pH, Fleigh value and digestibility of haylage. Molasses with the highest WSC was add to kudzu haylage resulted the lowest spoilage and pH, then increased both digestibility and Fleigh value (>100). The result was similar to that of Azizah *et al.* [23], who reported that molasses addition resulted in a lower pH than that of control and other treatments. The different carbohydrate

sources influence the anaerobic bacteria that reduce pH condition then inhibit the growth of mold which are not desirable for haylage quality. The digestibility increases showed that these additives also improve the forage quality to feed ruminants [15].

CONCLUSION

Based on the physical characteristic, nutrient composition and digestibility of Kudzu could be preserved as haylage with additives of rice bran, pollard, palm kernel and molasses. The best treatment on Kudzu haylage was 5% molasses addition that improved physical characteristics, nutrient composition, Fleigh value and digestibility.

CONFLICT OF INTEREST

The authors declare no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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