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Differences in chemical composition and nutrient quality of swamp forage ensiled

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Abstract

Forage plays an important role in the production of ruminants, but the availability of excellent quality, quantity and continuity of effort is still very limited. the purpose of this study was to determine the effect of the use of different inoculant silage nutritional quality of forage swamp. The research was conducted in Basic Science Laboratory of Agriculture college at UNISKA in Banjarmasin. The experimental design used was completely randomized with 3 treatments and 4 replications, there were 12 experimental units. S1 = Swamp forage + rumen fluid, (S2) : Swamp forage + *L. plantarum* 1BL–2, and (S3) = Swamp forage + molases. Results showed that silage with Plantarum 1BL-2 was considered good quality with pH 3.84), Total or Lacto acid bacteria (LAB) (7.8 x 10^8cfu/ml), amonia ($N\text{-}NH_3$) (90.12g N/kg), volatile fatty acid (VFA) (108.72mM), water soluble carbohydrate (WSC) (2.83% DM), dry matter (DM) digestibility (63.21%), Organic matter (OM) digestibility (62.32%). Quality of nutrition showed DM (25.95%), protein (13,96%), crude fiber (14.89%), ether extract (8.42%), and ash (7.72%). Score of the silage was 88.23, which was falling within the range of 80-100, considered good quality of silage. Concluded that the swamp forage silage can be used as animal feed.

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Introduction

Problems faced in forage production are availability and low quality. Scarce of forage in dry season could caused by lack of forage preserving effort during heavy production period. This condition made agroidustry by product, such as palm kernel waste, cassava waste, coconut waste, that hold high potency as forage source and available all year, became waste. South Kalimantan with 235,676 ha of swamp area, is potential for agriculture, fishery, farm estate, and forestry (Noor, 2007). Only 41.81% (equal to 143,118 ha) of total swamps area already utilized (Anonim, 2010). Swamp area has great potency to supplying forage (Kumpai grass and legume) for ruminants such as local buffalo (Kalang buffalo), cattle, and goat, especially during dry season. However, due to limited information on identification of grass and legume in the area, their nutrition content and production rate, as well as technology to improve the intake of these forages (Fariani and Eviyati, 2008). Among technology available, ensiling is one of the technologies that can be applied to overcome the problem in sustainable availability of forage (Widyastuti, 2008). The purpose of this research was to evaluate ensiling process and nutrient quality of forage from the swamp area.

Materials and methods

This research was conducted in Basic Science Laboratory of Agriculture college at UNISKA in Banjarmasin.

Materials

Materials used were swamp forage (60 % grass: 40 % legume), rice husk, inoculant of rumen fluid, *Lactobacillus plantarum* 1BL-2 isolated from tropical forage (Widyastuti *et al*, 1998), molasses, 12 pcs of 50 kg plastic silos, wood, bamboos, celotape, and labelling. The ratio of each swamp forage used was grass Kumpai Batu (*Ishaemum Polystachyum,* J.Press) 20.44% and Kumpai Minyak (*Hymenagnechne amplexiacaulis,* Rudge Nees) 39.55%; while the legumes were Pipisangan (*Jussicea linifolia vahl*) 18.83 and Beberasan (*Persicaria barbata* (L) H. Hara) 21.16%. The nutrient composition is displayed in Table 1.

Methods

Experimental design used was completely randomized design with 3 treatments and 4 replications, there were 12 experimental units. The forage was chopped in 3-5 cm size, laid for 4 -5 hours until total moisture decrease to 60 %, then added with 5% DM of rice husk. These materials then treated with:

S1 : added with rumen fluid as much as 1 ml/ kg of forage

S2 : added with *L. plantarum* 1BL–2 as much as 1 ml/ kg forage or around 10^6 cfu/g forage.

S3 : added with molases 3 % of forage

These ingredients were then put into silos, packed, and closed tightly, fermented for 21 days, then harvested. The silage kept in open air then sampled for laboratory analysis. Variables evaluated were dry matter (DM), organic matter (OM), pH, lactic acid bacteria (LAB) in log 10 cfu/ml by total plate count method, total Volatile Fatty Acid, VFA, (AOAC, 1999) and organic acid using (HPLC).

Differences between variables were analyzed with ANOVA with post test using Duncan Muliple Range Test (Steel and Torrie,1997).

Results and discussion

Physical characteristics

The ensilage treatments did not affect the color of the swamp forage silage (Table 2). These colors reflected the component of forage colors and rice husk. Browning and broken silage were caused by high dry matter content and *Clostridia* will cause rancidity.

The flavor of these silages were all about acid; however, the one with rumen fluid was stronger than silage with *plantarum* B1 and molasses. These silages might be heterofermentative, that their final product was not only lactic acid but also acetate, propionate, butirate, and alcohol. It was suspected that silage with rumen fluid produced alcohol and acetate higher that caused stronger acid flavor; whereas silage with *plantarum* 1BL-2 and molases were dominated with lactate that made them not too strong. Good silage smells like milk due to its lactate content not strong flavor (Saun and Heinrichs, 2008).

The texture of the three silages were in good condition, solid; showing a little deterioration of the components of the silage. This was due to the moisture content of the forage prior to fermentation was as required at 60%. The texture of the silage was affected by the moisture of the forage at the beginning of the fermentation; >80% moisture will cause jelly-like, soft, and fungous texture, but with (<30%) moisture will cause dried texture and fungous too (Macaulay, 2004).

Table 1. Nutrition quality of swamp forages used in ensilage process (Rostini, 2014).

Nutrient (%)	Kumpai Minyak	Kumpai Batu	Pipisangan	Beberasan
Crude protein	10.88	14.36	15.96	16.45
Ether extract	1.2	1.29	0.85	0.61
Crude fiber	16.37	17.35	25.23	16.27
NDF	62.6	40.38	24.48	56.42
ADF	62.6	39.26	23.83	51.62
Hemicelulose	36.75	1.12	0.65	4.8
Celulose	25.85	25.77	20.07	34.03
WSC	0.12	4.71	6.55	2.85

Quality of Nutrients of Swamp Roughage Silage

Dry matter of these silages were all (< 30%) higher than that of in *Panicum maximum* grass. There were some kinds of grass that was used as one the components of the silage and their protein content was similar to this grass. Highest crude protein recorded from Plantarum 1BL-2 silage while highest crude fiber recorded from rumen fluid silage. Ether extract in molasse silage was the lowest (6.80%) while all ash contents were seemed unchanged.

Table 2. Physical characteristics of 21 day swamp forage swamp silage.

Characteristics	rumen fluid	Plantarum 1BL-2	Molases
Color	green and yellow	green and yellow	green and yellow
Flavor	strong	lactic acid	acid
Texture	solid	solid	solid

Nd: not detected.

Chemical analysis of silage

Results of chemical analysis of the silage consisting of N-NH_3, VFA, DM digestibility, and OM digestibility were displayed in Table 4.

Concentration of N-NH_3 of silage added with molasses significantly lower ($p<0.05$) than silages innoculated with rumen fluid and L.plantarum 1BL2. It could be concluded that *L. plantarum* ensiled the forage better than molasse. The highest N-NH_3 was found in *L. plantarum* 1BL-2 silage (90.12 gN/kg). During ensiling, protein was broken down into peptide and amino acids by enzymes within the forage (McDonald, 1991) and more soluble (Santoso *et al.*, 2007). However, the amino acids were then broken down into ammonia (N-NH_3) and Non Protein Nitrogen (NPN) by *Clostridia*. This bacteria will be suppressed when the pH was low due to the existence of the Plantarum 1BL2. The N -ammonia is an indicator of the amount of N total degraded during ensiling; therefore, NH_3 is the indicator of a secondary fermentation Chamberlain and Wilkinson

(1996). The amount of N-NH3 inside silage determined quality of silage. Best silage has NH3 less than 50 gN/kg N total and good silage has NH3 between 50-100 g N/kg N total (Chamberlain and Wilkinson 1996). Based on these criteria silage inoculated with *L. plantarum* 1BL-2 was considered as best, while silage added with molasses and inoculated with rumen fluid was good silages.

Table 3. Quality of Nutrients of Swamp Roughage Silage after 21 days of ensiling.

Nutrient	fresh forage	rumen fluid	*L. Plantarum 1BL-2*	Molases	SEM
Dry matter	40.25	25.42a	26.71b	24.91a	7.32
Organic matter	80.79	74.23[a]	76.04[b]	75.54[b]	2.86
Crude protein	13.72	13.75[a]	14.02[b]	12.6[a]	0.63
Crude fiber	21.16	15.39[b]	13.89[a]	14.49[a]	3.34
NFE	50.97	51.82[a]	57.17[c]	53.47[b]	2.75
Ether extract	8.14	7.39[a]	8.13[b]	6.69[a]	0.69
NDF	56.17	48.86[a]	51.86[b]	51.19[b]	3.05
ADF	47.33	35.42[b]	33.75[a]	34.09[a]	6.5

The N-NH_3 plays as N source for rumen microbes digesting the feed; while VFA (Volatile Fatty Acid) as the end product of carbohydrate metabolism will be used as energy source for the animal and its product such as milk and meat in ruminants (McDonald *et al.* 2002). The microbial activity during ensiling process will help degrade protein in the forage such that protein will be more available available for rumen microbes and the animal as the host. The optimal N-NH3 concentration in the rumen system is 6-21 mM (McDonald *et al.*, 2002).

Table 4. Chemical composition and digestibility of the swamp forage silage after 21 days of ensiling.

Variable	rumen fluid	Plantarum 1BL-2	Molases	SEM
N-NH3 (g N/kg)	50.98	90.12	50.49	22.74
VFA (mM)	103.57	108.72	55.95	29.09
DM digestability (%)	59.23	63.21	60.46	2.04
OM digestability (%)	56.25	62.32	57.94	3.13

Different superscrip among treatment, different significantly ($P<0.05$).

Concentration of total VFA in silage with molasse was lower significantly ($P<0.05$) compared to those of rumen fluid and 1BL-2. This lower total VFA was caused by low concentrations in asetate, propionate, butirate, and valerate. This result showed that *L. plantarum* fermented silage in efficient way. Lower VFA total in silage with molasses was due to lower levels of asetate, propionate, butirate and valerate compared to S1 and S3. This suggested that ensiling with *L. plantarum IBL-2* was more efficient that does with molasses.

Good quality of silage is indicated with high concentrate of lactate silase; whereas, asetate, propionate, and butyrate is lower Ohishima and McDonald (1978). Acetate could be originated from carbon chain of amino acid during secondary fermentation. Butyrate is produced from breaking down of glucose and lactate by sacharolytic *Clostridia*. This bacteria worked antagonistically with *Plantarum*. On the other hand, other microbes wouldn't lower pH as effective as Plantarum, therefore the unwanted bacteria, *Clostridia* to grow.

Digestibility of DM and OM of silage after 21 days of fermentation were not significantly different among treatments even though silage of S3 has highest OM and DM digestibility. On average DM digestibility of silage produced between 55%–65%, and categorized as good silage (Preston and Leng, 1987). The lower digestibility in molases silage due to water content of molases that affect the fermentation, and Water Diluted Carbohydrate (WSC) that affect digestibility of DM (Chemey et,.al, 2004).

Microbiology Quality of Silage

Acidity of silage is known as the main criteria for the quality assessment for silage. During this study, Silage of S1 (rumen fluid) has significantly higher pH compared with other treatment ($p<0.05$) in Table 4. The pH levels of quality of silage as follows: pH 3.2–4.2 (very good), pH 4.2–4.5 (good), pH 4.5–4.8 (average), and pH >4.8 (low) (Macaulay, 2004). Based on pH value, all silages produced in this study could considered as good based (McCullough (1978) and very good on Macaulay's scale.

Table 5. Microbiology analysis of silage made of swamp forage after 21 days of fermentation.

Variable	rumen fluid	Plantarum 1BL-2	Molases	SEM
pH	4.09^{b}	3.84^{a}	3.85^{a}	0.14
Total LAB (x 10^8 cfu/ml)	5.5^{b}	7.8^{c}	2.2^{a}	2.81
Kadar N-amonia (%TN)	6.45	6.15	6.89	0.37
WSC	0.95^{a}	2.83^{b}	0.91^{a}	1.1
Fungi (%)	6.74	nd	3.84	-

Different superscript among treatments, different significantly ($p<0.05$).

Population of LAB found in S2 (Plantarum 1BL) significantly higher than other treatment The higher population of LAB in silage with Plantarum 1BL-2 after 21 days of ensiling may be due to it is originated from tropical fruit, in which contained much more energy and WSC available for fermentation.

Later, population of LAB will be diminishing during stable state as its acid will slow down its own growth. The LAB produced antibacteria components such as hidroxiperoxide that will reduce its growth (Lopez, 2000). Acid bacteria can grow well in the range of pH 4.0 - 6.8 McDonald *et al.* (1991).

Fungi appearance on the surface of a silo often exists in the ensilage process. Idealy, good silage does not have fungi on its surface. Data showed that silage with plantarum 1A-2 had 6.74% fungi and the molases was lower (3.84 %), while in plantarum 1BL-2 silage was not found any fungi after 21 days ensilage. These finding were lower than that of at any silage containing 10% of fungi (Jaelani *et al.* 2014).

Conclusion

Silage made of swamp forage with *Plantarum* 1BL-2 was considered the best based on physical characteristic, nutritive values, in vitro digestibility, and microbiology test.

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