Quality of Vegetable Waste Silages Treated with Various Carbohydrate Sources

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Abstract

The aim of this research was to evaluate the quality of vegetable waste silages, using rice bran, onggok (cassava flour waste) and pollard as carbohydrate sources. Vegetable waste was collected from local traditional market, consisted of corn husk, chinese cabbage dan cabbage. Research was held in Randomized Block Design consisted of six treatments with 3 replications. Treatments were (T1) vegetable waste+rice bran, (T2) vegetable waste+rice bran+rice straw, (T3) vegetable waste+onggok, (T4) vegetable waste+onggok+rice straw, (T5) vegetable waste+pollard, (T6) vegetable waste+pollard+rice straw. Lactobacillus plantarum 1A-2 was used as innoculant. The quality of silages was evaluated by measuring pH, temperature, population of lactic acid bacteria and lactic acid production. Nutrient characteristic was determined by proximate and fiber analysis. Results showed that pH of silages were not affected by treatments, but silage treated with rice bran, with or without rice straw addition, had higher temperature compared with others (29oC or 28,3oC). The highest population of lactic acid bacteria (1.9 x 107cfu/ml) was found in silage using rice straw and onggok (T4), but highest lactic acid production (0,91) was measured in silage using rice straw and rice bran (T2). In general, the use of rice bran as carbohydrate sources gave highest lactic acid production followed by pollard and onggok. Different carbohydrate source gave different nutrients characteristic. Silage with highest protein content was measured in silage with pollard as carbohydrate source, followed with rice bran and onggok.

Keywords: Lactobacillus plantarum 1A-2, onggok, pollard rice bran, vegetable waste silages

Introduction

Forage is major feed for ruminant, but increasingly difficult to obtain due to competing land uses with human interests. Therefore, it is necessary to find new resources that can substitutes the forage. Vegetables waste is a potential feed source for ruminant, to overcome lack of grass, especially in dry season. Vegetable waste is part of the vegetables that are not consumed by humans, usually already discarded by traders, so has no economic value. Traditional farmers already give vegetable waste to their cattle, but its high water content made it easily decayed and cannot be stored for long period. This limitation increased the cost and difficulties in handling because farmers have to take vegetable waste from traditional market everyday. Treatment is necessary to improve the quality and the nutritional value of vegetable waste as feed.

Silage production is a method of moist forage preservation which is widely used all over the world (Saele, 2002). It is based on natural fermentation when lactic acid bacteria (LAB) ferment water soluble carbohydrates to organic acids, mainly lactic acid, under anaerobic conditions. As a result, the pH decreases, inhibiting detrimental anaerobes, and so the moist forage is preserved (Merry and Davies, 1999). A combination of anaerobic condition and acidity protects the forage from the proliferation of deleterious bacteria and fungi, and it also increases the palatability of the forage due to lactic acid production (Yang *et al*., 2001, Weinberg *et al*., 2003, Filya, 2003).

In terms of storage, silage is more durable because of spoilage bacteria do not resistant to low pH, so its availability and quality of feed can be assured. Silage can also be used as probiotics and organic acid sources for livestocks as an alternative to antibiotics. In order to improve the ensiling process and to obtain a high-quality fermented product, various chemical and biological additives have been developed and used during silage fermentation. The biological additives are advantageous because they are safe and easy to use, non-corrosive to machinery, do not pollute the environment and are regarded as natural products (Filya *et al*., 2000; Weinberg and Muck, 1996). Seale *et al.* (1986) found that sugar is a limiting factor in producing good-quality fermented products. Sugar mainly serves as a carbon source for microorganisms. Molasses, lactose and a mixture of cereal grains and malt, dextrose, corn or tapioca flour have been used as additives (Zahar *et al*., 2002).

A successful ensiling process requires a minimum concentration of fermentable sugars (3-5% in DM). However, the majority of carbohydrates in plants are in the form of fibrous polymers that make up the cell wall and are not fermented by lactic acid bacteria (LAB). In order to obtain the necessary level of fermentable water-soluble carbohydrates (WSC) for the lactic fermentation in crops which are low in WSC, the use of carbohydrate sources has been suggested.

Research on the ensiling of vegetable waste is still limited, and the effects of different additives may vary from one to another, resulting variety of resulting silages. Therefore, the objective of this experiment was to evaluate the quality of vegetable waste silages, using rice bran, onggok (*cassava flour waste*) and pollard as carbohydrate sources.

Materials and Methods

Vegetable waste was collected from local traditional market in Bogor, consisted of corn husk, chinese cabbage and cabbage. After chopping, vegetable waste was air dried to decrease water content. It was sprayed with *Lactobacillus plantarum* 1A-2 as an innoculum and divided into equal portions for the application of treatments. All innocula were diluted with distilled water, so that they were applied at the same rate (10 ml of solution/kg of vegetable waste).

Experiment was held in a randomized block design consisted of six treatments with 3 replications. Treatments were (T1) vegetable waste + rice bran, (T2) vegetable waste + rice bran + rice straw, (T3) vegetable waste + onggok, (T4) vegetable waste + onggok + rice straw, (T5) vegetable waste + pollard, (T6) vegetable waste + pollard + rice straw.

Each treatment was packed into ±15 L plastic drum as silos in triplicate and sealed. Silos were stored at room temperature. After 45 days ensiled, each silo were sampled for chemical and microbial analyses. The DM content was determined by oven drying for 48 h at 60 ^{o}C. After drying, samples were ground through a 1-mm screen miller, and stored in glass bottle at room temperature for chemical (proximate and fiber) analysis. The quality of silages was evaluated by measuring pH, temperature, population of lactic acid bacteria and lactic acid production. Nutrient characteristic was determined by proximate and fiber analysis at Laboratory of Feed Technology, IPB.

Another portion of original sample was diluted with autoclaved distilled water and blended in high-speed blender for 30 s. The diluted samples were enumerated for LAB on pour-plates using MRS agar (DeMan, Rogosa, and Sharpe) with TPC (Total Plate Count) method, cultivated at 30 °C for 48 hours (modification from Cappucino and Sherman, 1983). Colonies were counted from plates of appropriate dilutions containing a minimum of 30 colonies. pH was immediately measured from the remainder of diluted sample.

Results and Discussion

Quality of silage can be observed from the physical characteristics of the resulting silage. After 45 days of ensiling, vegetable waste silage in this study exhibiting a yellowish green color, fresh aroma and not slimy. There was only a few fungal contamination visually observed on the surface of the silage due to aerobic conditions. Those physical characteristic indicated a successful fermentation process. Use of rice bran, onggok (cassava byproduct), and pollard as source of carbohydrates in each treatment resulted in only a little color differences of silages. Silage using onggok had a lighter color while silage using pollard and rice bran had a darker color. Physical appearance of vegetable waste silages from each treatment can be seen in

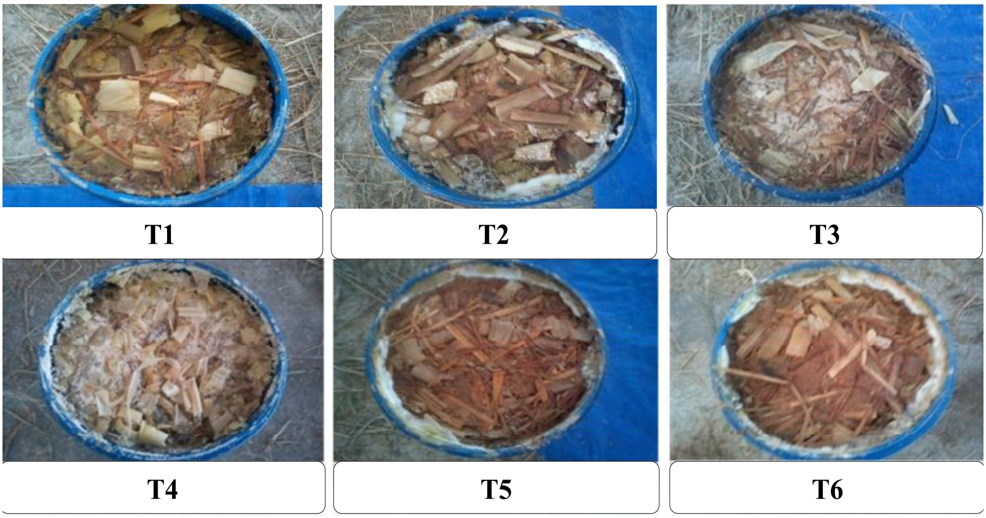

Figure 1. Physical appearance of vegetable waste silages. T1= vegetable waste + rice bran; T2= vegetable waste + rice bran + rice straw; T3= vegetable waste + onggok; T4= vegetable waste+ onggok + rice straw; T5= vegetable waste + pollard; T6= vegetable waste + pollard + rice straw.

Other variables for evaluating silage quality is the chemical (temperature, pH and lactic acid production) and microbiological (LAB population) characteristics of silage presented in Table 1. Temperature of silage at the end of fermentation varied between treatments. The highest temperature was recorded (29 ^{o}C) on silage with rice bran addition (T2), which was significantly higher compared to others.

Value of pH, lactic acid production, and population LAB were not signifantly affected by carbohydrate sources addition. Vegetable waste silages treated with ong-

Table 1. Chemical and microbiological characteristics of vegetable waste silages

	Treatments					
	T1	T2	T3	T4	T5	T6
Temperature (^{o}C)	28.33 ± 0.01^{b}	29.00 ± 0.00^{b}	27.00 ± 0.00^{a}	27.33 ± 0.57^{a}	27.33 ± 0.57^{a}	27.00 ± 0.00^{a}
pH	3.91±0.01	3.94±0.04	3.42±0.46	3.55±0.42	3.91±0.09	3.72±0.19
Lactic acid (%)	0.41±0.10	0.30±0.05	0.23±0.01	0.29±0.11	0.30±0.06	0.36±0.11
LAB (cfu/g)	$7.10x10^{8}\pm 4.98x10^{8}$	$10.40x10^{9}\pm 4.10x10^{8}$	$6.97x10^{8}\pm 3.59x10^{8}$	$16.5x10^{9}\pm 8.97x10^{8}$	$6.71x10^{8}\pm 2.08x10^{8}$	$5.48x10^{8}\pm 3.06x10^{8}$

Note: LAB= Lactic Acid Bacteria; T1= vegetable waste + rice bran; T2= vegetable waste + rice bran + rice straw; T3= vegetable waste + onggok; T4= vegetable waste + onggok + rice straw; T5= vegetable waste + pollard; T6= vegetable waste + pollard + rice straw.

gok gave the lowest pH value (3.42 and 3.55), while the highest pH value was obtained from silages treated with rice bran (3.91 and 3.94). This condition may relate to the acidity of onggok which was lower than rice bran and pollard. A pH range of 3.7-4.2 was generally considered to be beneficial for crop preservation (Kung and Shaver, 2001), but according to Bates *et al*. (1996), pH ranged between 3 and 4 was still considered adequate.

High quality silage is likely to be achieved when lactic acid is the predominant acid produced, as it is the most efficient fermentation acid, and reduces silage pH (McDonald *et al*., 2002), thus lactic acid production was correlated with pH value. Higher lactic acid production would result in lower pH value, but in this experiment, some silages with low lactic acid production also had low pH value. Lactic acid production in this study was ranged between 0.23–0.41%, with no significant differences among treatments. Silages treated with onggok (T3) had the lowest lactic acid production compared to other carbohydrate sources. According to Coblentz (2003), onggok have low WSC content (3%), while rice bran and pollard have higher WSC content (5% and 12%). Low WSC content means low nutrient sources served for LAB to produce lactic acid.

Lactobacillus plantarum 1A-2 added as inoculants during silage making to increase population of lactic acid bacteria, in order to stimulate lactic acid fermentation, accelerate the decrease in pH, and thus improve silage preservation of homo - fermentative lactic acid bacterial strains. These bacteria produce large amounts of lactic acid in the silage in a short time and stabilize it with minimal losses (Filya, 2003). In general, different carbohydrate sources had not influenced population of lactic acid bacteria significantly. The highest population of LAB was observed in silages with onggok addition (T4) (16.5 x 10^9 cfu/g), while pollard addition (T6) produced silages with the lowest population of LAB (5.48 x 10 cfu/g ^{8}).

Table 2. Nutrient composition of vegetable waste silages

Nutrient (%)	Treatments					
	T1	T2	T3	T4	T5	T6
DM	86.57	88.44	88.54	90.75	91.64	87.21
Ash	26.46	15.37	2.52	7.59	5.84	9.61
CP	7.51	9.40	3.56	4.59	14.52	13.45
CF	25.79	28.15	14.26	19.76	10.99	16.41
EE	1.70	0.30	0.12	1.01	0.19	1.15
NFE	25.11	35.22	68.08	57.80	60.10	46.59

Note: DM= Dry Matter; CP= Crude Protein; CF= Crude Fiber; EE= Ether Extract; NFE= Non Fiber Extract; T1= vegetable waste + rice bran; T2= vegetable waste + rice bran + rice straw; T3= vegetable waste + onggok; T4= vegetable waste + onggok + rice straw; T5= vegetable waste + pollard; T6= vegetable waste + pollard + rice straw.

Ensiling has been a preferential method in maintaining the energy content of forages, ensuring a good nutritional value when used as feed (Vervaeren *et al*., 2010). Table 2 shows nutrient characteristics of vegetable waste silages after 45 days of ensiling. Use of pollard as carbohydrate source gave the highest CP content (14.52%) than other treatments, while the use of onggok provided the lowest CP content of vegetable waste silages (3.56%). This result is correlated with CP content of carbohydrate sources added in silage production. Pollard has CP content around 15%, while rice bran and onggok have only CP content around 11% and 2% (Furqa-anida, 2004). Sapienza and Bolsen (1993) stated that CP content of qood quality silage ranged between 10.50%-15.20%. Above the optimum range will result in poor silage quality and cannot be stored for a long time due to biochemical reactions between amino acids and sugars causing the Maillard reaction which produced brown silage.

The contents of CF and EE in vegetable waste treated with rice bran were the highest in all silages (28.15% and 1.70) as predicted, because rice bran had the highest CF and EE content compared with other carbohydrate sources used in this experiment. Silage with EE content more than 2% will be easily contaminated and classified as bad quality of silage (Sapienza and Bolsen, 2003). The highest EE in this experiment was 1.70% indicating a good quality of silage.

Fiber compositions of silages were not affected significantly by treatments (Table 3). The use of rice straw as silage material increased the value of NDF, compared with silages without rice straw (T2 vs T1, T4 vs T3, T7 vs T6), and also increased lignin content of silages except for T2. Neutral detergent fiber (NDF) is related to the filling effects of feeds in the rumen. Pollard addition (T5 and T6) resulted in the lowest NDF, ADF, cellulose and lignin contents in silage, but exhibiting the highest level of hemicelluloses (33.09%). Use of onggok as carbohydrate source resulting in the highest cellulose content (49.55%) and lowest hemicelluloses (4.18%).

Table 3. Fiber composition of vegetable waste silages

Fiber (%)	Treatments					
	T1	T2	T3	T4	T5	T6
NDF	58.77	72.69	58.28	76.44	52.96	56.33
ADF	51.59	49.65	33.37	72.26	19.87	32.43
Hemicellulose	7.18	23.04	24.91	4.18	33.09	23.90
Cellulose	33.44	30.41	23.71	49.55	16.70	22.38
Lignin	10.77	10.24	9.03	18.14	2.67	5.27

Note: NDF= Neutral Detergent Fiber; ADF= Acid Detergent Fiber; T1= vegetable waste + rice bran; T2= vegetable waste + rice bran + rice straw; T3= vegetable waste + onggok; T4= vegetable waste + onggok + rice straw; T5= vegetable waste + pollard; T6= vegetable waste + pollard + rice straw.

Conclusions

Physical characteristic of vegetable waste silages was good, with a yellowish green colour and good aroma, indicating that fermentation process was successful. Use of rice bran, onggok (cassava byproduct), and pollard as carbohydrate sources for ensiling vegetable waste did not show significant differences in chemical and microbiological characteristics, nutrient and fiber compositions of resulted silages. It can be concluded that all carbohydrate sources used in this experiment can be use as silage additive resulting in a good vegetable waste silage.

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