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Physical Quality of Sago Waste Silage with Different Concentrations of Cattle's Rumen Liquid

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ABSTRACT. *Sago waste can be used as a substitute for carbohydrate feed sources but is constrained by the high content of crude fiber and low crude protein. Pretreatment with fermentation treatment is expected to improve the physical quality of silage. This study aimed to determine the addition of different concentrations of cattle's rumen liquid on the physical quality and pH of sago waste silage. The research design used a Completely Randomized Design with 4 treatments and 4 replications. Each treatment included: T0 = sago waste + 0% cattle's rumen liquid; T1 = sago waste + 2% cattle's rumen liquid; T2 = sago waste + 4% cattle's rumen liquid; T3 = sago waste + 6% cattle's rumen liquid. The result showed the physical quality (color, aroma, and texture) was very significant (P<0.01) influenced by the addition of different concentrations of cattle's rumen liquid, and the pH of silage was not significant (P>0.05) effect. Sago waste silage which was the addition of 6% cattle's rumen liquid gave the best physical quality, judged by light brown color (3.518 ± 0.02), the distinctive aroma of silage (3.61 ± 0.04), dense texture, crumbly, and not slimy (3.58 ± 0.02), as well acidic pH (4.40 ± 0.18).*

Keywords: Ccattle's rumen liquid, physical quality, sago waste, silage.

INTRODUCTION

Sago plants are one of the high carbohydrate-producing plants that are widely spread in eastern Indonesia, one of which is Riau, namely 82.713 ha (*Dinas Tanaman Pangan, Hortikultura dan Perkebunan Provinsi Riau*, 2019). The area is directly proportional to the sago waste processing industry's sago production. The total sago produced in Riau reached 364.233 tons (*Dinas Perkebunan Provinsi Riau*, 2018).

The high production of sago is followed by an increase in the waste produced, around 81.5% is dominated by sago waste (Rianza et al., 2019). The abundance of sago waste is generally allowed to accumulate, so it needs to be used to minimize environmental pollution. One of the proper uses of sago waste is to make it as ruminant animal feed because it contains 65.7% starch/NFE (nitrogen-free extract), which has the potential to be used as a substitute for energy source feed (Simanihuruk et al., 2017). The use of sago waste as feed is limited by its high crude fiber content (30.14%) and low crude protein content (4.37%) (Rianza et al., 2019). Mucra et al. (2020) added that the digestibility and palatability of sago waste were still low thereby, effort is necessary to improve the quality of sago waste so that it can be used as a feed source. This effort can be done by processing it into fermented feed as silage.

Nuraini (2015) reported that the fermentation treatment in the form of silage was able to change beneficial physical and chemical properties, such as breaking down complex

compounds into easily digestible compounds in the presence of microorganisms and producing a texture, aroma, and taste that livestock liked. The role of Lactic Acid Bacteria (LAB) and cellulolytic microorganisms is required to make silage. LAB are necessary to produce lactic acid, while cellulolytic bacteria act as breakers of the bond of cellulose and lignin (Datta et al., 2019). The fermentation process requires a starter to speed up and optimize the fermentation process to produce quality silage. One of the local waste-based starters that can be used as inoculum material in the fermentation process is cattle's rumen liquid.

Cattle's rumen liquid is a local resource resulting from animal slaughter waste from Slaughterhouse, which need to be managed optimally to reduce environmental pollution. The amount of rumen liquid produced by one cattle reached 31 liters (Sundayanti et al., 2016). The abundance of cattle's rumen liquid has the potential to be used as a starter in making silage, which can speed up the fermentation process because it contains a number of microbes that help the process of breaking down complex compounds into easily digestible compounds so that produce quality silage. According to Pratama (2013), rumen liquid contains bacteria up to 10^9/mL consisting of cellulolytic bacteria such as *R. albus, R. flavefaciens, Fibrobacter succinogens*, and hemicellulolytic bacteria such as *Eubacterium ruminantum* and *Bacteriodes ruminocola*. Cellulolytic bacteria have a very high cellulolytic activity to hydrolyze complex cellulose into easily digestible compounds with the help of the resulting cellulase enzymes (Yogyaswari et al., 2016). In addition, in the cattle's rumen liquid, there are lactic acid bacteria whose effectiveness can produce quality silage (Datta et al., 2019).

Several researchers have carried out many processing of fermented feed in the form of silage using cattle's rumen liquid, including Datta et al. (2019) who used the Bali cattle's rumen liquid as a bio-activator in fermented corn forage was able to produce silage with a fresh sour aroma, yellowish to green-brown color, and the pH is in the normal range based on the silage pH standard. Research relating to the physical quality of silage using sago waste as the main ingredient and cattle's rumen liquid inoculum has never been reported. The study aims to determine the effect of different concentrations of cattle's rumen liquid on the physical quality (aroma, color, and texture) and pH of sago waste silage.

MATERIALS AND METHODS

Location and Time

This study was conducted at the Laboratory of Nutrition and Feed Technology, Faculty of Agriculture and Animal Science, State Islamic University of Sultan Syarif Kasim Riau in November – December 2021

Materials and Tools

The sago waste used as the primary material is fresh sago waste obtained from the sago processing factory in Selat Panjang, Kepulauan Meranti Regency, Riau Province. The starter used as an inoculum material is cattle's rumen liquid, which is obtained directly from the Pekanbaru City Slaughterhouse.

The equipments used included masks, gloves, gauze, masking tape, plastic funnels, analytical balances, manual scales, glass bottles, silo bottles, plastic basins, flasks, tarpaulins, blenders, pH meter, tissues, stationery, thermometers, mercury, room thermometer, and digital camera.

Research Materials Preparation

The sago waste taken from the Selat Panjang was immediately dried under the sun until it reached the water content of 7% to avoid reactions during the samples were brought to Pekanbaru City. Before the sample is fermented, water is added to obtain the required water content according to the fermentation standard,

which is 70%. Subsequently, the samples were weighed according to the treatment.

Cattle's Rumen Liquid Collection

Cattle's rumen liquid was obtained directly from the rumen bag of cattle slaughtered at the Pekanbaru city Slaughterhouse by taking the contents of the middle part of the rumen, then squeezed and filtered, and collected as soon as possible using two layers of gauze over a plastic funnel that has been connected to the hole in the thermos. Warm water was added to create optimal rumen temperature (39°C). The thermos was tightly closed and taken to the research location to be immediately used as a starter.

Material Mixing, Packaging, and Sample Fermentation

Sago waste and cattle's rumen liquid that have been prepared are mixed and stirred evenly in a plastic basin according to the treatment until homogeneous. The sample is immediately put and compacted into a silo bottle until it reaches anaerobic conditions (without oxygen), then tightly closed and wrapped using tape until the bottle is dark. The sample code is given according to the treatment and stored for up to 14 days of fermentation.

Research design

The study was designed using a completely randomized design (CRD) consisting of 4 treatments and 4 replications. Each treatment included T1 = Use of 0% cattle's rumen liquid, T2 = Use of 2% cattle's rumen liquid, T3 = Use of 4% cattle's rumen liquid, T4 = Use of 6% cattle's rumen liquid.

Observation Indicator

Observational indicators in this study included measuring pH and physical quality assessment (color, aroma, and texture).

Physical Quality Analysis

In the physical quality analysis, samples that had been fermented for 14 days were opened and taken as much as 5 g from each treatment to observe the physical quality (organoleptic) by involving the senses of 60 untrained panelists, including color (sight sense), texture (tactile sense), and aroma (smell sense) by giving a score to each indicator according to the characteristics of the resulting silage (Table 1). Meanwhile, pH measurements were carried out with a pH meter by taking 3 g of sample for each treatment, diluted with 30 mL of distilled water, and mixed for 1 minute using a blender. The resulting water filtered and measured the pH value.

Table 1. Standards of physical quality assessment of sago waste silage

Indicator	Characteristics	Score
pH**	Very good	3.2 – 4.2
	Good	4.2 – 4.5
	Bad	>4.8
Color***	Light brown	3 – 3.9
	Brown	2 – 2.9
	Dark brown	1 – 1.9
Aroma*	Acid	3 – 3.9
	No acid/no rotten	2 – 2.9
	Rotten	1 – 1.9
Texture *	Solid (crumbs, not clumpy, and not slimy)	3 – 3.9
	Slightly mushy (fairly slimy and clumpy)	2 – 2.9
	Mushy (watery, clumpy, and slimy)	1 – 1.9

Sources: * Alvianto et al. (2015)
** Kurniawan et al. (2015)
*** Datta et al. (2019)

Statistical Analysis

The data obtained were analyzed by analysis of variance based on a completely randomized design followed by Duncan Multiple Range Test for further testing to determine the significancies between treatment.

RESULTS AND DISCUSSION

The pH of Sago Waste Silage

The degree of acidity (pH) is the main comparison in assessing the quality and storability of silage from agricultural industrial waste, which is closely related to total lactic acid produced during the ensilage process. The best pH value of silage ranged from 3.2 – 4.2, the good category was 4.2 – 4.5, and the bad category was >4.8. Prabowo (2013) stated that a low pH value indicated excellent silage quality, but the higher pH value, the worse silage quality. The low pH value in silage indicates the metabolic activity of lactic acid bacteria which produce lactic acid by breaking down substrates into lactic acid (Aglazziyah et al., 2020).

Data presented in Table 1. showed the addition of 0-6% cattle's rumen liquid had no significant effect (P>0.05) on the pH value of sago waste silage but resulted in a low pH value (4.2 – 4.5) which indicates the good quality silage. This proves that there is the same activity of Lactic Acid Bacteria (LAB) after being given 0-6% rumen liquid in sago waste silage, whereas in the treatment without rumen liquid (0%) lactic acid bacteria are already present in sago waste. The activity of a number of microorganisms, especially lactic acid bacteria found in rumen liquid and sago waste in breaking down carbohydrates is capable of producing the same lactic acid so that the resulting pH is also the same. This is supported by the statement of Kurniawan et al. (2015) that the lactic acid bacteria from cattle's rumen liquid can increase the number of bacteria which shortens the ensilage process, resulting in a decrease in pH.

The values of the pH measurement results obtained in this study are in line with the results of a research report by Jasin and Sugiyono (2014) which added Ongole Crossbreed cattle's rumen liquid 10^6 CFU/g forage containing lactic acid-forming bacteria as an inoculant capable of producing a pH value of 3.65 – 4.60 on elephant grass silage. The same result was reported by Sandi et al. (2010), the addition of 1% rumen liquid/kg of material to cassava-based silage showed pH values of 3.66 – 4.86.

Table 2. Physical quality of sago waste silage with different concentrations of cattle's rumen liquid

Treatments	Parameters			
	pH	Color	Aroma	Texture
T0 = SG + 0% RL	4.46 ± 0.21	3.430^{a} ± 0.02	3.52^{a} ± 0.02	$3,35^{a}$ ± 0,03
T1 = SG + 2% RL	4.55 ± 0.27	3.428^{a} ± 0.01	3.55^{a} ± 0.02	$3,43^{b}$ ± 0,02
T2 = SG + 4% RL	4.32 ± 0.14	3.440^{a} ± 0.02	3.56^{a} ± 0.04	$3,54^{c}$ ± 0,01
T3 = SG + 6% RL	4.40 ± 0.18	3.518^{b} ± 0.02	3.61^{b} ± 0.04	$3,58^{d}$ ± 0,02

Note: Means in the same column with different superscripts differ significantly (P <0.01). SW= Sago Waste; RL= Rumen Liquid.

The Color of Sago Waste Silage

Indicators in determining good silage standards can be seen from the colors produced. Silage improves if the color produced is close to the silage material which is generally brownish and yellowish green depending on the raw materials used, while colors that deviate from the original color, it means poor quality silage (Alvianto et al., 2015). Daud et al. (2014) reported that the silage color was influenced by the color of the raw materials and additives.

The results of this study are shown in Table 2, the addition of 0-4% cattle's rumen liquid did not significantly (P>0.05) affect the color of sago waste silage, the scores obtained were 3.430 – 3.440 with a light brown color similar to the color of sago waste which in this case indicates good quality silage. However, the color of sago waste silage was very significant (P<0.01) when the rumen liquid was added up to 6% with a score of 3.518 and a lighter brown color. This is thought to be the effect of a large number of bacteria from rumen liquid (10^6/mL rumen liquid) that utilize the substrate in sago waste so that the fermentation process is more optimal than the 0-4% treatment and causes the sago waste to get closer to its original color. Kurniawan et al. (2015) stated that the more similar silage is to the original color of the raw materialwhich is a good quality silage.

The data resulted in this study are higher than those reported by Kurniawan et al. (2015), which showed that silage of agricultural waste from a combination of tofu waste, brown skin, cocoa shell, palm kernel meal, elephant grass, corn cobs, cassava and cassava peel with the addition of 4% rumen liquid inoculum as a local microorganism produced a silage color that was dark with a score of 1.20.

The Aroma of Sago Waste Silage

Aroma is an indicator that is interrelated with other indicators in determining quality silage. Silage is of high quality if the aroma produced is a distinctive aroma of fermentation. The distinctive aroma of fermentation indicates that the anaerobic fermentation process is running optimally in producing lactic acid (Kurniawan et al., 2015). Data analysis of variance showed that the different concentrations of cattle's rumen liquid had a very significant effect (P<0.01) on the aroma produced by sago waste silage.

Based on the data presented in Table 2, showed the addition of 0-4% cattle's rumen liquid was not significantly different (P>0.05) affect the aroma of sago waste silage with scores of 3.52 - 3.56 that produces an acidic aroma which in this case indicates good quality silage. This shows that adding 0-4% cattle's rumen liquid can activate the optimal growth of microbes, especially lactic acid bacteria in producing lactic acid during the fermentation process, resulting in the same aroma, which is a distinctive aroma of fermentation. In line with the statement of Naif et al. (2016), fermentation activates the growth and metabolism of microorganisms to produce a distinctive aroma of fermentation. In addition, it is also thought to be due to giving the rumen liquid concentration which is still relatively low. These results are similar to the research of Kurniawan et al. (2015) used cattle's rumen liquid starter at a level of 4% in agricultural waste silage able to produce an acidic aroma with a score of 2.63.

The aroma of sago waste silage was significantly (P<0.01) sourer when the cattle's rumen liquid was increased up to 6% with a score of 3.61. This is thought to be due to the more metabolic activity of lactic acid-producing bacteria in breaking down carbohydrates into lactic acid during fermentation compared to the addition of 0-4% rumen liquid. The formation of lactic acid has an impact on lowering the pH value which prevents the growth of putrefactive bacteria, resulting in an acidic aroma without a bad smell. Rukana et al. (2014) reported that the sour aroma in the silage is a sign of ongoing fermentation involving the activity of lactic acid bacteria to break down carbohydrate compounds to form lactic acid. The sour aroma obtained in silage is thought to come from the reaction of LAB after utilizing glucose in the plant during the fermentation process to produce lactic acid (Fitriawaty, 2020).

These results have statistically proven that increasing the cattle's rumen liquid from 4% to 6% affects the aroma produced by sago waste silage. The results obtained with scores of 3.52-3.61 are similar to those reported by Datta et al. (2019), corn straw silage treated with lactic acid bacteria $6x10^8$ CFU/mL from Bali cattle's rumen

liquid resulting in a score of 2.28 with a fresh sour aroma.

The Texture of Sago Waste Silage

In the process of quality assessment of silage, the texture is included in an indicator that is closely related to the physical quality of silage, the higher level of texture density obtained, the higher the quality of the silage product produced. The good silage improves if the texture produced is similar to the original texture of the material used, which is solid and not mushy (Alvianto et al., 2015).

The data obtained (Table 2.) showed that the different concentrations of cattle's rumen liquid starter had a very significant ($P<0.01$) effect on the texture of sago waste silage in all treatments with a score each treatment sequentially T0 (0% RL) of 3.35; T1 (2% RL) of 3.43; T2 (4% RL) of 3.54, and T3 (6% RL) of 3.58 with a crumb, dense and not slimy texture. Those scores indicate that the best texture obtained was in the P3 treatment by giving 6% rumen liquid. This data is almost similar to the research data reported by Kurniawan et al. (2015) who used 4% rumen liquid starter in agricultural waste silage was able to produce a texture similar to the silage material with a score of 2.80 and have a dense and not mushy texture.

Based on the assessment results, the addition of cattle's rumen liquid improved the texture of sago waste silage. Sago waste silage becomes more crumbly, denser, and less slimy when the concentration of rumen liquid given is increased, this is because rumen liquid contains cellulolytic bacteria. Cellulolytic bacteria can decompose complex carbohydrate structures into glucose by breaking cellulose and lignin bonds so that the higher the concentration of rumen liquid added, the higher the population of cellulolytic bacteria that work in overhauling cell walls by breaking cellulose and lignin bonds during fermentation to produce the dense, crumbly and soft texture of silage. This suspect refers to the statement of Yogyaswari et al. (2016) that in the liquid rumen, there are various types of microbe, including cellulolytic bacteria with a high cellulolytic activity resulting in the production of cellulase enzymes which function in hydrolyzing cellulose complex compounds into glucose. In addition, Hidayat et al. (2012) added that the texture of the silage produced by the crumbs indicated that the silage was successful due to the ensilage process was taking place due to the presence of microbes. Therefore, in this study, the more liquid rumen given, the more cellulolytic bacteria work to break down the cell walls, resulting in a very good sago waste silage texture.

CONCLUSION

Sago waste processed with the addition of a concentration of 6% cattle's rumen liquid, capable of giving the best physical quality, judged by light brown color (3.518 ± 0.02); a distinctive sour aroma of silage (3.61 ± 0.04); a crumbly, dense, and non-slimy texture (3.58 ± 0.02), as well acidic pH (4.40 ± 0.18).

CONFLICT OF INTEREST

The authors declare that there is no anything conflict of interest.

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