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Production Performance of Sheep with Pineapple Peel Silage-Based Ration

Achmad Raisman Saeful Mumin, Lilis Riyanti*, & Kenedy Putra
Department of Animal Husbandry, Bogor Agricultural Development Polytechnic, Indonesia
Jl. Snakma Cisalopa, Caringin, Bogor
**Corresponding author*: riyantililis23@gmail.com

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ABSTRACT. *The study aimed to analyze the effect of pineapple peel silage in the ration on production performance and to assess the income level of sheep farmers using pineapple peel silage as a based ration. The study was designed in randomized block design with 3 treatments and 3 replications. The treatments consisted of P0 = control diet with 100% field grass, P1 = field grass + pineapple peel silage with 3% of rice bran, and P2 = field grass + pineapple peel silage with 6% rice bran. The diet ratio of grass to pineapple peel silage in the diet was 80:20. Variables measured included dry matter intake, daily weight gain, feed efficiency and Income Over Feed Cost (IOFC). The results showed that the dry matter intake of sheep treated with P1 was significantly higher (P<0.05) than that of P0 and P2. The daily weight gain of sheep treated with P2 was 70.83 g/day, which was not significantly different from P0 and P1 but had a higher numerical value. Feed efficiency and IOFC did not show significant difference (P>0.05). The results of the economic analysis indicated an increase in farmer income with the use of silage, particularly at P2 with an income of IDR 534,284. In conclusion, the use of pineapple peels silage as ration for sheep increased dry matter intake and had a positive impact on farmer income.*

Keywords: Income, sheep, production performance, pineapple peel silage

INTRODUCTION

Sheep are one of the primary meat-producing livestock in Indonesia. They are widely cultivated due to several advantages such as being prolific (producing more than one lamb), fast-breeding, a reliable source of animal protein, highly adaptable, and providing valuable by-products. For instance, their manure can fertilize agricultural land and their hides can be used for decoration purposes. In 2021, West Java Province had the largest sheep population in Indonesia, with approximately 12,2 million heads. These sheep are distributed across several districts in West Java, including Subang Regency (Statistics of Subang Regency, 2021).

According to the data from the Central Statistics Agency of Subang Regency in 2021, the sheep population in Subang was 265.164 heads (Statistics of Subang Regency, 2021). This The population is spread across several Subdistricts in Subang Regency, one of which is Ciater Subdistrict, which has a sheep population of 5.178 heads. In addition to its significant livestock population, particularly sheep, Ciater Subdistrict also boasts abundant agricultural production especially in fruit cultivation. Pineapple is a key crop, with total production 68,7 tons/year. Pineapple (*Ananas comosus*) is a tropical fruit with an edible portion comprising 30-45% of its total weight (Gasmi et al., 2021). It is valued not only for its unique aroma and sweetness but also for its nutritional benefits,including antiinflammatory and antioxidant properties (Nguyen et al., 2019).

Given the abundant production of pineapples, there is significant potential to utilize by-products such as pineapple peels and crowns, which account for 70–75% of the fruit's total weight (Zeng et al., 2023). These by-products are rich in nutrients, with crude protein levels ranging from 7.51–8.81% in the crown,

peel, and pomace, compared to 5.18–6.54% in the bud end and core (Kiatti et al., 2023). Pineapple by-products are composed of dietary fibers, flavonoids, minerals, sugars, polyphenols, and vitamins, which contribute to their roles in antibiosis, antioxidation, and gastrointestinal protection (Hu et al., 2019). One promising application of pineapple peel by-products is their use as animal feed.

Pineapple peels contain 8.78% crude protein, 17.09% crude fiber, 23.45% ADF, and 64.05% NDF (Raguati et al., 2018). Furthermore, a study by Saputro et al. (2022) found that pineapple silage has a nutrient composition of 8.36% crude protein, 4.17% ether extract, 25.98% crude fiber, and 45.55% NFE. The use of pineapple by-products as a substitute for forage in complete feed, at substitution levels of up to 70%, has been shown to improve overall nutritional quality, including increased crude protein and ether extract, while reducing crude fiber, NDF, and ADF (Mucra et al., 2023). For example, substituting 50% pineapple peel silage in a corn silage-based diet for black goats increased feed intake and daily weight gain to 80 g/head/day (Yang et al., 2022).

In this study, the inclusion of pineapple peel silage in sheep rations will be examined at levels of up to 20%, considering that previous studies have shown positive impacts on animal performance at substitution levels of up to 50%. The study aims to analyze the effects of pineapple peel silage utilization on sheep performance and evaluate the income levels of sheep farmers who incorporate pineapple peel silage into their sheep rations.

MATERIALS AND METHODS

The study consisted of silage preparation, feeding trial and measurement of variables. The material used included pineapple peel silage, rice bran, molasses, Effective Microorganism-4 (EM_4), field grass, silo, a digital scale, feed containers. Nine rams were used for the feeding trial.

Pineapple Peel Silage Production

Pineapple peels were obtained from pineapple traders in Ciater Subdistrict. The peels were chopped into 2-3 cm pieces. A total of 50 kg of pineapple peels were weighed and spread on a tarpaulin. Rice bran was added at 3% of a total weight of pineapple peels for treatment 2 and 6% for treatment 3. Effective Microorganism 4 (EM_4) was prepared by pouring three bottle caps (±15 ml) into 500 ml of water (Riyanti & Febriza 2023). The EM_4 mixture was evenly poured over the pineapple peels while stirring to ensure proper distribution. The pineapple peels mixture was then placed into the silo layer by layer, compacted and tightly sealed. The silage was incubated for 21 days at room temperature. After incubation, the silage was removed from the silo to evaluate its quality (colour, aroma and texture) and determine its suitability for feeding to sheep.

Feeding Trial

The study used nine rams aged 12–24 months, with an average body weight of 17.98 kg. The ration consisted of field grass and pineapple peel silage. The sheep were housed in individual cages, and partitions were placed in the feed bins. The animals were adapted to the silage diet for 7 days, and the feeding trial was conducted for 30 days. Dry matter (DM) intake was calculated according to Siregar (1994), where sheep with a body weight of 15 kg and a daily weight gain of 150 g/head/day require a DM intake of 3.5% of body weight (875 g), with TDN requirements of 61.94%, PK 8.8%, Ca 0.34%, and P 0.24%. The ration provided consisted of field grass and pineapple peel silage in a ratio of 80:20.

Variables Measurement

Dry matter intake (DMI)

Dry matter intake was calculated as the difference between the amount of feed given and

the amount of residual feed, expressed in g/head/day.

Dry Matter Intake (DMI) = Feed intake (g/head/day) x % DM of feed

Average daily gain (ADG)

Average daily gain was calculated as the difference between the final body weight and the initial body weight, divided by the number of days. Body weight was measured every 10 days (0, 10, 20, 30, and 40 days). Daily gain was calculated using the formula according to Supratman et al. (2016).

Feed efficiency

Feed efficiency was calculated as the quotient of daily body weight gain and DM intake.

***Income over feed cost* (IOFC)**

Income over feed cost (IOFC) was calculated using the following formula according to Ulfa *et al.* (2019).

IOFC = [ADG (kg) x Price/kg BW (Rp)-[DM intake (kg) x feed prices (Rp)]

Business feasibility analysis

The feasibility of fattening sheep for 40 days with nine heads was analyzed. The calculated variables included the Benefit Cost Ratio (B/C ratio), Revenue Cost Ratio (R/C ratio), Break-Even Point (BEP) price, and BEP production.

Design Experiment and Data Analysis

The study was designed using a Randomized Block Design with three treatments and three replications. The treatments consisted of P0 = control (100% field grass), P1 = field grass + pineapple peel silage with 3% rice bran, and P2 = field grass + pineapple peel silage with 6% rice bran. Data were analyzed using analysis of variance (ANOVA). If significant differences were found between treatments, a further test using the Least Significant Difference (LSD) was conducted (Steel & Torrie 1995).

RESULT AND DISCUSSION

The results of observations on the physical quality of pineapple peel silage are shown in Table 1. Based on the observed silage characteristics, it can be concluded that all silage treatments exhibited good physical quality, characterized by a green, yellowish-green, or brownish color, a sour aroma, and a texture that generally remained close to its natural state (Yang et al., 2022). The color of the pineapple peel silage ranged from green to yellowish-brown, resembling the color of fresh, ripened pineapple peels. The aroma was a fresh, acidic scent with a unique fragrance, and the texture was soft and relatively fibrous (Wimalasiri & Somasiri, 2021). The brown color observed in the silage is influenced by the Maillard reaction, a non-enzymatic browning reaction between reducing sugars and free amino groups of amino acids, which releases heat (Riyanti & Febriza, 2023).

Table 1. Physical quality of pineapple peel silage

Silage Treatments	Physical quality		
	Colour	Aroma	Texture
P1	Green-browning	acidic	Moist
P2	Yellow-browning	acidic	Moist

Note: P1 = pineapple peel silage + EM_4 + 3% rice bran. P2 = pineapple peel silage + EM_4 + 6% rice bran.

Fermentation characteristics are key indicators of the fermentation process. One of the observed fermentation characteristics of silage is its pH value. Based on pH measurements, the pineapple peel silage had a pH of 3.58. After 21 days of ensiling, the silage quality was determined to be very good, as it falls within the range of 3.2–4.2, which is categorized as "very good" according to Putri et al. (2020). The quality of silage based on pH is

classified into four groups: very good (pH 3.2–4.2), good (pH 4.2–4.5), moderate (pH 4.5–4.8), and poor (pH > 4.8).

The measurement result for average dry matter (DM) intake, daily gain, feed efficiency and IOFC for sheep treated with field grass (control, P0), pineapple peel silage with 3% rice bran (P1), and pineapple peel silage with 6% rice bran (P2) could be seen in Table 2.

The results showed that the inclusion of pineapple peel silage in sheep rations resulted in a significant difference (P<0.05) in dry matter intake and income over feed cost (IOFC), but no significant difference (P>0.05) was observed in daily body weight gain and feed efficiency. Based on the LSD test, sheep treated with pineapple peel silage containing 3% rice bran (P1) showed higher dry matter intake and lower IOFC values compared to those treated with pineapple peel silage containing 6% rice bran (P2).

Table 2. Production performance of sheep with pineapple silage based-ration

Parameters	Treatment		
	P0	P1	P2
DM intake (g/head/day)	574.52±1.78^{c}	601.40±1.08^{a}	593.86±4.91^{b}
Daily gain (g/head/day)	62.75±7.79	61.58±13.87	70.83±14.12
Ration Efficiency (%)	10.92±1.33	10.24±2.31	11.91±2.32
IOFC (IDR)	102.60±33.96	145.57±57.31	147.67±30.30

Note: Means in the same row with different superscripts differ significantly (P <0.05).

The ANOVA analysis revealed a significant difference (P<0.05) in dry matter intake due to the inclusion of pineapple peel silage. The dry matter intake values for treatments P0, P1, and P2 were 574.52, 601.40, and 593.86 g/head/day, respectively. The use of pineapple peel silage with 3% rice bran (P1) increased dry matter intake in sheep. The higher dry matter intake in P1 and P2 suggests that pineapple peel silage has better palatability compared to the control ration. However, the increase in dry matter intake did not translate into improvements in daily gain or feed efficiency. Regarding dry matter intake, Kearl (1982) suggested that growing sheep with a live weight of 20 kg and a daily gain of 100 g require a daily dry matter intake of 410 g, or 3.5% of live weight. Additionally, the NRC (1985) recommends that sheep weighing 10–20 kg require a dry matter intake of 0.5–1 kg, or 5% of live weight. Thus, the rations provided in this study meets the criteria recommended by Kearl (1982). In comparison, Sari (2022) reported a higher dry matter intake of 665.9 g/head/day in sheep. The use of pineapple peel silage in rations for West African dwarf sheep with a body weight of 9–10.5 kg positively affected daily intake and daily gain (Oduguwa et al., 2020).

The inclusion of pineapple peel silage did not result in a significant difference in daily gain (P>0.05). Sheep treated with pineapple peel silage containing 6% rice bran (P2) showed a tendency for higher daily gain (70.83 g/head/day) compared to other treatments. Although feed intake in this treatment was lower, it resulted in a higher daily weight gain compared to P1, indicating that P2 silage is more efficient in promoting weight gain. The 20% inclusion level of pineapple peel silage in this study may explain the lack of significant improvement in daily gain. Livestock growth is influenced by nutrient intake, particularly energy consumption. Furthermore, Sari (2022) stated that fluctuations in average daily gain (ADG) are strongly influenced by variations in feed intake. For comparison, Oduguwa *et al*. (2020) reported a daily weight gain of 66.43 g/head/day when using ensiled cassava peels and pineapple peel fruit waste.

The results showed that the utilization of pineapple peel silage in the ration did not result in a significant difference (P>0.05) in feed efficiency for sheep in the P0, P1, and P2 treatments, with values of 10.29%, 10.24%, and 11.19%, respectively. This result aligns with the lack of significant response in daily weight gain observed in the sheep. The inclusion level of pineapple peel silage was relatively low (only 20%). However, the P2 treatment showed a tendency to have the highest feed efficiency value compared to the other treatments. Feed efficiency is defined as the ratio of the amount of product produced (body weight gain) to the amount of feed intake over the same period (Sari et al., 2022).

Feed efficiency can be determined by comparing the amount of ration consumed with the body weight gain produced during a specific maintenance period (feed conversion). A higher feed efficiency value indicates that the ration is utilized more effectively to produce body weight gain.

The results of the study also showed that the inclusion of pineapple peel silage in sheep rations did not significantly affect the income over feed cost (IOFC) value (P>0.05). The IOFC values for sheep in the P0, P1,and P2 treatments were Rp102,600, Rp145,575, and Rp147,672, respectively. The IOFC value is influenced by both income and the cost of feed intake. Nevertheless, the average IOFC values for P1 and P2 were higher than that of the control (P0). Higher body weight gain typically leads to a more optimal IOFC, but the insignificant differences in IOFC values among treatments in this study may be due to variations in the initial body weight of the sheep. A higher IOFC value indicates better economic efficiency of the ration consumed by the sheep. IOFC is used to determine the effectiveness of a ration in increasing livestock productivity. A high IOFC value is achieved by selecting cost-effective ingredients for the ration (Sari et al. 2022).

An economic analysis is necessary to determine whether the results of the applied study, when viewed economically, can be recommended to farmers. This study must be analyzed economically to assess differences in profitability and determine which treatment provides higher profits. The results of the economic analysis of pineapple peel silage utilization are presented in Table 3.

Table 3. Business analysis of sheep feed with pineapple peel silage ration

Variables	Treatment		
	P0	P1	P2
Revenue (Rp)	437.584	453.284	534.284
B/C ratio	0.119	0.105	0.115
R/C ratio	1.119	1.105	1.115
BEP price (Rp)	67.006	67.848	67.211
BEP production (kg)	48.50	56.89	61.06

Note: P0= control with 100% field grass, P1= field grass + 3% rice bran pineapple peel silage, and P2= field grass + 6% rice bran pineapple peel silage.

Table 3 shows the business analysis of the three treatments. The most profitable treatment is the third treatment (P2), as it provides the highest income of Rp534,284. The second highest income is from the second treatment (P1), with an income of Rp453,284, while the lowest income is from the first treatment (P0), with an income of Rp437,584. Among the three treatments, P2 is the most profitable. Therefore, for sheep fattening businesses aiming for the highest profit, the third treatment (P2) is recommended.

The B/C ratio is used to determine the feasibility level of a business. The B/C ratio for P0 is 0.119, meaning that for every Rp1,000

spent, a profit of Rp119 is generated. The B/C ratio for P1 is 0.105, indicating a profit of Rp105 for every Rp1,000 spent. The B/C ratio for P2 is 0.115, meaning a profit of Rp115 for every Rp1,000 spent. Based on the B/C ratio values, all three treatments are profitable.

The R/C ratio is used to compare revenue to expenditure. The R/C ratio values for P0, P1, and P2 are 1.119, 1.105, and 1.115, respectively. All three treatments have an R/C ratio value greater than 1, indicating profitability. The Break-Even Point (BEP) price for each treatment is as follows: P0 (Rp67,006), P1 (Rp67,848), and P2 (Rp67,211). This means that P0, with a total production of 48.50 kg, will break even if the product is sold at Rp67,006/kg. P1, with a total production of 56.89 kg, will break even at Rp67,848/kg, and P2, with a total production of 61.06 kg, will break even at Rp67,211/kg.

The production BEP (Break-Even Point) indicates the body weight of sheep that must be achieved to break even. For P0, the production BEP is 48.50 kg, meaning the sheep must reach this weight to break even at a selling price of at least Rp67,006/kg. To make a profit, the selling price must exceed Rp67,006/kg. For P1, the production BEP is 56.89 kg, requiring a selling price of at least Rp67,848/kg to break even, with profits achievable at prices above this level. For P2, the production BEP is 61.06 kg, requiring a selling price of at least Rp67,211/kg to break even, with profits achievable at higher prices.

CONCLUSION

Pineapple peels can be preserved as silage and used in sheep rations. The utilization of pineapple peel silage at 20% in sheep rations increases dry matter intake. The inclusion of pineapple peel silage in sheep rations can also enhance farmers' income.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organizations related to the material discussed in the manuscript.

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