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RESEARCH ARTICLE
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Production Responses of Goats to Corn Plant Silage from Different Varieties Cultivated in Rice Fields during the Dry Season

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ABSTRACT

Seasonal feed shortages during the dry season present a major constraint to ruminant production in Indonesia. Corn silage is a practical solution to ensure consistent forage availability, but the performance of goats fed with different silage varieties remains unclear. This study evaluated the effects of corn-plant silage made from two varieties, Lamuru (a local composite) and Pioneer P32 (a hybrid), on feed intake, nutrient digestibility, rumen fermentation profile, and growth performance of Kacang goats. Ten male goats (8–12 months old) were randomly assigned to two dietary treatments consisting of 60% corn-plant silage and 40% concentrate. Corn plants for silage are cultivated in rice fields during the dry season. Feed intake, nutrient digestibility, ruminal pH, ammonia nitrogen (NH_3-N), total volatile fatty acids (VFA), average daily gain (ADG), feed conversion ratio (FCR), and feed efficiency were assessed. Results indicated non-significant differences ($P>0.05$) between treatments for most variables, including feed consumption, digestibility, fermentation parameters, and production performance, except for ADF digestibility, which was higher ($P<0.05$) in goats fed with Pioneer P32 silage. These findings suggest that both corn varieties are suitable for silage production in rice fields during the dry season and can be used effectively in small ruminant feeding systems.

Keywords: Corn-plant silage, Kacang goats, Feed intake, Digestibility, Growth performance

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INTRODUCTION

The sustainability of ruminant farming in Indonesia faces numerous challenges, with one of the most critical being the limited availability of quality feed. This problem has broad implications, including reduced grazing land, the nature of native grasses that grow and mature quickly with low biomass and nutrient content, and wide fluctuations in forage production between rainy and dry seasons (Sudaryanto & Priyanto, 2010; Manu, 2014; Rinduwati, 2017). Idle land used as a grazing area in Indonesia experienced an average annual decline of 3.81% from 2010 to 2015 (BPS 2011, 2016). Grazing lands in Indonesia are dominated by natural grass and weeds, resulting in low production and nutritional content (Siba et al., 2017; Hae et al., 2020; Amah et al., 2022). Although efforts have been made to improve feed production and quality, the problem remains unresolved. This is evident from the declining ruminant population, with an average annual decrease of 7.97% between 2020 and 2024 (BPS 2022, 2025). Therefore, innovations are urgently needed to enhance the quality, quantity, and continuity of ruminant feed.

One promising strategy to ensure year-round feed availability is the production of silage. Silage refers to green forages with a moisture content of 50% or more that are preserved through controlled fermentation in silos (Bolsen et al., 2007; McDonald et al., 2011). It can be made from various plant sources such as corn (*Zea mays* L.), alfalfa (*Medicago sativa* L.), forage grasses, cereal crops, green legumes, leguminous trees, and agricultural by-products (Rotz et al., 2003; Moran, 2005; McDonald et al., 2011; Syawal et al., 2020). Among these, corn-plant silage is the most widely used, particularly in dairy and beef cattle systems (Zhang et al., 2022).

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According to García-Chávez et al. (2022), corn used for silage generally falls into three categories: hybrid, local, and genetically modified organisms (GMOs). Certain hybrids have been reported to influence silage biomass and nutrient content (Millner et al., 2005; Semenčenko et al., 2014; Nazli et al., 2019). However, another study by Neumann et al. (2021) suggests that while some hybrids differ in nutritional composition, others do not. The impact of feeding corn-plant silage on livestock performance has been documented in cattle, dairy cows and fattening operations (Balakhial et al., 2022; Luo et al., 2022; Nafisah et al., 2023; Tarnonsky et al., 2023; Hasan et al., 2024). Feeding corn-plant silage has been shown to improve dry matter intake, organic matter, crude protein, and NDF digestibility (Juniper et al., 2005; Nazli et al., 2018; Tayyab et al., 2019; Olijhoek et al., 2022). In goats, corn-plant silage increased feed intake, digestibility, and average daily gain compared to Napier grass silage (Khaing et al., 2015). On the other hand, studies in Holstein cattle have reported non-significant effects of corn hybrid silage on intake, digestibility, rumen fermentation, or milk yield (Bal et al., 2000; Weiss & Wyatt, 2002; Ferraretto et al., 2015). However, Saleh (2016) reported that feed consumption in several varieties of corn silage did not differ significantly, but resulted in different daily weight gain in goats.

Our previous research showed non-significant differences in biomass production or nutrient content between hybrid and local composite corn varieties cultivated in rice fields during the dry season (Purnomo et al., 2025). However, their effects on nutrient consumption, digestibility, rumen fermentation and production performance in goats have not been evaluated. Therefore, this study aimed to determine the influence of feeding silage from hybrid and local composite corn varieties on feed intake, nutrient digestibility, rumen fermentation profile, and growth performance of goats.

MATERIALS & METHODS

This study used 10 male Kacang goats aged 8 to 12 months. The goats were randomly divided into two treatment groups:

- P1: 60% Lamuru corn-plant silage + 40% concentrate
- P2: 60% Pioneer P32 corn-plant silage + 40% concentrate

Corn plants for silage were cultivated in rice fields during the dry season (June–September 2023) in Sidenreng Rappang Regency, South Sulawesi Province (3.837026°S, 119.856988°E). The feed ingredients used for each treatment are presented in Table 1.

The nutrient contents of the feeds are summarized in Table 2.

Table 1: Feed composition in each treatment (% dry matter basis)

Feed Ingredients	P1	P2
Forage (%)		
Lamuru Silage	60	
Pioneer P32 Silage		60
Concentrate (%)	40	40
Rice Bran	16	14
Corn milling	16	16
Soybean Meal	3.6	6
Meal	4	5.6
Mineral Mix	0.4	0.4

Table 2: Nutrient composition of corn-plant silage and concentrate (% dry matter basis)

Nutrient (%)	P1	P2
Corn-plant silage:		
- Dry Matter (DM)	46.78	40.01
- Organic Matter (OM)	96.06	96.03
- Crude Protein (CF)	10.77	9.72
- Ester Extract (EE)	1.70	2.41
- Crude Fiber (CF)	28.22	28.84
- Nitrogen Free Extract (NFE)	55.37	55.05
- Minerals	3.94	3.97
- ADF	34.45	39.52
- NDF	64.69	66.71
- Cellulose	29.10	32.84
Concentrate:		
- Dry Matter (DM)	88.37	88.55
- Organic Matter (OM)	94.51	94.34
- Crude Protein (CF)	15.01	17.35
- Ester Extract (EE)	7.86	7.89
- Crude Fiber (CF)	8.76	9.18
- Nitrogen Free Extract (NFE)	62.88	59.93
- Minerals	5.49	5.66

Measured Parameters

The parameters observed in this study included feed consumption (dry matter, organic matter, protein, and crude fiber), digestibility (dry matter, organic matter, protein, and crude fiber), rumen fermentation profile (pH, volatile fatty acids, and NH_3-N content) and production performance (daily weight gain, feed conversion ratio and feed efficiency).

Data Collection

Goats were housed in individual metabolic cages (100 × 50 cm) equipped with trays for feces and urine collection. Feed was offered twice daily (morning and afternoon). Data collection started on day 7 after feed adaptation. The amount of feed offered and refused was recorded daily to calculate intake. Body weight was measured every 14 days to adjust concentrate levels.

Digestibility data were collected after measuring growth performance. Goats were offered feed at 80% of average intake for three consecutive days. Feces and feed samples were collected on days 3 to 5. Nutrient contents (dry matter, organic matter, crude protein, crude fat and crude fiber) were analyzed using AOAC methods (AOAC, 2012), while ADF and NDF were analyzed by following the methodology of Van Soest et al. (1991).

Rumen fluid was collected 3 hours after the morning feeding using an esophageal tube. The liquid was filtered through double-layered cheesecloth and paper for analysis. Rumen pH was measured using a digital pH meter. Ammonia-N was determined using the Conway method (Conway & O'Malley, 1942), and total VFA was measured by steam distillation (Millar, 1966).

Feed digestibility was calculated using the equation:

$$Digestibilty\ (\%) = \frac{Nutrients\ Consumtion - Nutrient\ in\ Feses}{Nutrients\ Consumtion} x\ 100\%$$

Production performance was measured by weighing goats at the beginning and end of the research. Average daily gain (ADG) was calculated by subtracting initial body weight from final body weight, then dividing by the number of maintenance days. Feed conversion ratio was determined using the formula:

$$FCR = \frac{Feed\ Consumtion\ (g/d\ DM)}{ADG\ (g/d)}$$

The feed efficiency ratio was calculated by using the formula:

$$FER = \frac{ADG\ (g/d)}{Feed\ Consumtion\ (g/d\ DM)} x100\%$$

Data Analysis

Data were analyzed using an independent sample T-test under a Completely Randomized Design (CRD). Statistical analyses were performed using IBM SPSS version 23. A significance level of $P<0.05$ was used to determine treatment effects.

RESULTS

Nutrient Consumption

Goats fed with Lamuru and Pioneer P32 corn-plant silage showed comparable average daily intakes of dry matter (490.82g/d and 479.53g/d, respectively), organic matter, crude protein, crude fat, crude fiber, nitrogen-free extract (NFE), minerals, acid detergent fiber (ADF), neutral detergent fiber (NDF), and cellulose. Statistical analysis indicated non-significant differences between the two treatments for any nutrient consumption parameter. The detailed results of nutrient consumption are presented in Table 3.

Table 3: Nutrient consumption of goats fed with Lamuru (P1) and Pioneer P32 (P2) corn-plant silage

Nutrient consumption	P1	P2
Dry matter (% BW)	2.59±0.17	2.64±0.18
Dry matter (g/d)	490.82±68.35	479.53±49.65
Organic matter (g/d)	468.62±65.14	457.52±47.27
Crude protein (g/d)	60.66±8.79	60.06±6.74
Crude fat (g/d)	19.67±3.27	21.20±2.61
Crude fiber (g/d)	102.70±12.86	105.77±10.07
NFE (g/d)	285.60±40.37	272.58±28.52
Minerals (g/d)	22.19±3.21	22.02±2.39
ADF (g/d)	105.71±12.33	119.93±11.06
NDF (g/d)	198.50±23.16	202.46±18.67
Cellulose (g/d)	89.30±10.42	99.66±9.19

P1 = Lamuru Corn Plant Silage, P2 = Pioneer P32 Corn Plant Silage

Nutrient Digestibility

Digestibility of dry matter, organic matter, protein, crude fiber, NFE, minerals, and NDF did not differ significantly between goats fed with Pioneer P32 and Lamuru corn-plant silage. However, ADF digestibility was significantly higher ($P<0.05$) in goats fed with Pioneer P32 (54.19%) compared to those fed with Lamuru silage (46.82%). The detailed results of nutrient digestibility are presented in Table 4.

Table 4: Apparent nutrient digestibility in goats fed Lamuru (P1) and Pioneer P32 (P2) corn-plan silage

Digestibility (% DM)	P1	P2
Dry Matter (DM)	71.30±1.54	70.39±3.08
Organic Matter (OM)	71.45±1.73	70.65±3.12
Protein	72.21±0.90	71.63±3.82
Crude Fiber (CF)	65.27±2.80	66.18±3.05
Nitrogen Free Extract (NFE)	72.54±0.92	71.03±3.48
Minerals	68.29±4.22	65.14±4.61
ADF	46.82±4.20^{b}	54.19±4.99^{a}
NDF	53.96±4.93	56.77±4.49

Same row with different subscripts indicates a significant difference ($P<0.05$).
P1 = Lamuru corn-plant silage, P2 = Pioneer P32 corn-plant silage

Rumen Fermentation Profile

Goats fed with Lamuru and Pioneer P32 corn-plant silage had rumen pH values of 6.74 and 6.80, NH_3-N concentrations of 12.88mM and 14.21mM, respectively, and VFA levels of 33.46mM and 40.85mM. Statistical analysis revealed non-significant differences in pH, VFA, or NH_3-N concentrations between the two treatments. The detailed results of rumen fermentation profiles are presented in Table 5.

Table 5: Rumen fermentation profile of goats fed with Lamuru (P1) and Pioneer P32 (P2) corn-plant silage

Parameter	P1	P2
pH	6.74±0.05	6.80±0.07
Total VFA (mM)	33.46±9.56	40.85±3.92
RumenNH3-N (mM)	12.88±6.91	14.21±3.04

P1 = Lamuru corn-plant silage, P2 = Pioneer P32 corn-plant silage

Goat Performance

Goats fed with Lamuru and Pioneer P32 corn-plant silage showed non-significant differences in initial and final body weights, average daily gain (ADG), or percentage daily gain. The average ADG was 61.90g/day in P1 and 73.10g/day in P2. Feed conversion ratios (FCR) based on dry matter, organic matter, and protein were similar across treatments, as were feed efficiency ratios (FER), indicating that both corn-plant silage types supported comparable growth and efficiency outcomes in goats. The detailed results of goat performance are presented in Table 6.

Table 6: Performance of goats fed with Lamuru (P1) and Pioneer P32 (P2) corn-plant silage

Parameter	P1	P2
Goat Weight		
- Initial (kg)	17.48±3.10	15.73±2.69
- Final (kg)	21.19±4.11	20.11± 2.70
- Weight gain (kg)	3.71±1.45	4.39±1.38
- Average Daily Gain (ADG) (g/d)	61.90±24.10	73.10±23.01
- Percentage of Daily Gain (% of initial body weight)	0.35±0.10	0.48±0.16
Feed Conversion Ratio		
- DM	8.48±2.08	7.09±2.43
- OM	8.10±1.98	6.76±2.31
- Protein	1.05±.25	0.89±.32
Feed efficiency ratio		
- DM (%)	12.43 ±3.38	15.33 ±4.62
- OM (%)	13.02±3.54	16.06±4.83
- Protein (%)	100.54±26.84	122.57±36.76

P1 = Lamuru corn-plant silage, P2 = Pioneer P32 corn-plant silage

DISCUSSION

The dry matter intake in this study aligns with the standard range reported by Sahoo et al. (2010), who stated that goats and sheep typically consume 2–4% of their body weight in dry matter daily. The observed intake levels also agree with findings from other studies on Kacang and local goats in Indonesia (Muktiani et al., 2020; Tahuk et al., 2021; Tahuk and Bira, 2022; Sayuti et al., 2024) and internationally (Morais et al., 2018; Win Muang & San, 2020; Phesatcha et al., 2021). According to Sahoo et al. (2010), feed intake in small ruminants is influenced by physiological factors, including maintenance, growth, reproduction, lactation, activity, and environmental conditions.

The absence of differences in nutrient consumption between goats fed with different corn-plant silage varieties (Lamuru and Pioneer P32) is consistent with studies in dairy cattle, which reported similar outcomes when different corn-plant silage hybrids were used (Bal et al., 2000; Weiss

and Wyatt, 2002; Ferraretto et al., 2015; Saleh, 2016). Uniformity in feed processing and nutrient composition between the two silage types likely contributed to the similar intake levels. Similar findings were also reported when cattle were fed different silage types, including grass, wheat, and beet-based rations (Phipps et al., 1995). However, Juniper et al. (2005) & Nazli et al. (2018) observed increased intake when corn-plant silage was replaced with grass silage or rice straw, respectively. Factors influencing feed intake in ruminants include animal weight, body condition, stage of production, level of milk production, forage quality, processing methods, amount and type of supplement or feed provided, and environmental conditions (Phesatcha et al., 2021; Malik et al., 2023; Lalman & Holder, 2024). Nutrient digestibility in both treatments is consistent with goats consuming complete rations containing fermented oil palm frond extract (Febrina et al., 2021), but lower than those reported for goats fed with natural grass, sorghum, or *Pennisetum purpupoides* silage (Tahuk et al., 2021). However, these values are higher than those reported in studies where goats were fed corn straw or *Pennisetum purpureum* (Khaing et al., 2015; Tahuk and Bira, 2022; Irawan et al., 2024). The digestibility values also match those observed in goat (Saleh, 2016); sheep (Sudweeks et al., 1979), heifers (Baxter et al., 1980) and Sahiwal cattle (Nazli et al., 2018). However, Di Marco et al. (2005) reported lower digestibility (52.9%) for corn-plant silage in Holstein cattle.

The similarity in digestibility outcomes between treatments agrees with previous research in Holstein cattle (Bal et al., 2000; Weiss and Wyatt, 2002; Ferraretto et al., 2015). However, Saleh (2016) reported that the same hybrid has different digestibility. Factors influencing digestibility include crop maturity, chop length, silage density, and processing techniques (Johnson et al., 2003; Sucu et al., 2016; de Souza et al., 2021). Feed particle size, chemical composition, processing methods, and animal age also significantly affect digestibility (Kassa Zewdie, 2019). Rumen pH in this study was slightly lower than values reported for Kacang goats fed with tropical grasses (Ismartoyo et al., 2024), but similar to values in Mahabadi goats (Saleh, 2016; Tarverdi Sarabi et al., 2023), dairy cattle (Ferraretto and Shaver, 2015) and Hu lambs (Jiao et al., 2025) fed with corn-plant silage. Total VFA and NH_3-N concentrations were within or near the normal physiological ranges for goats (McDonald et al., 2011; Bayne and Edmondson, 2021), although VFA levels were slightly lower than expected.

The lack of significant differences in rumen fermentation parameters between P1 and P2 is consistent with findings from Bal et al. (2000) and Weiss and Wyatt (2002), although Saleh (2016) & Jiao et al. (2025) reported varietal differences in goats and lambs. Similar nutrient compositions likely explain the comparable fermentation outcomes. Rumen fermentation is influenced by feed composition, processing, and additive use (Stern et al., 1985; Beauchemin, 1991; Kendall et al., 2009; Agle et al., 2010; Ma et al., 2015). Normal rumen pH (6.5–7.5), VFA (70–150mM), and NH_3-N (6–21mM) ensure optimal microbial activity and nutrient utilization (Li et al., 2022).The ADG of Kacang goats in this study is similar to goats fed diets with 17.5% corn straw (Muktiani et al., 2020), but higher than those fed natural grass or sorghum silage (Tahuk et al., 2021) and lower than those fed *Pennisetum purpureum* (Irawan et al., 2024). Performance values were also better than Korean native goats (Kim & Ko, 1995) and Chinese Boer goats (Wang et al., 2025). The relatively high ADG may be attributed to favorable intake and digestibility parameters.

Feed conversion ratios were comparable to previous findings in Kacang goats (Sayuti et al., 2024) and Korean goats (Kim and Ko, 1995), but higher than those in Boer goats (Khaing et al., 2015) and Italian Friesian cattle (Colombini et al., 2012). Feed efficiency ratios similarly reflected acceptable ranges and were consistent with goats fed with sorghum-based diets (Sayuti et al., 2024).

Corn variety did not significantly affect body weight gain, ADG, FCR, or FER. This aligns with studies in Holstein cows (Bal et al., 2000; Weiss and Wyatt, 2002; Ferraretto et al., 2015) but contrasts with Jiao et al. (2025), who reported varietal effects in lambs. Although ADF and NDF content differed slightly between P1 and P2, this did not translate into performance changes. Other studies support the impact of reduced fiber content on improved growth and efficiency in goats and cattle (Colombini et al., 2012; Khaing et al., 2015; Zhang et al., 2021).

Based on these findings, both Lamuru and Pioneer P32 corn-plant silages are suitable for dry-season cultivation in rice fields as ruminant feed. While Pioneer P32 showed numerically higher performance, it required more protein supplementation and comes with a higher seed cost, making Lamuru a cost-effective alternative depending on local production goals and economic considerations.

The overall findings of this study demonstrate that both Lamuru and Pioneer P32 corn-plant silage varieties, when cultivated in rice fields during the dry season, provide comparable nutritional quality and performance outcomes in Kacang goats. No statistically significant differences were observed between the two treatments in terms of nutrient intake, digestibility, rumen fermentation profile, or production performance. These results align with previous studies in both small ruminants and cattle indicate corn variety has a limited impact when nutrient profiles are similar and silage processing is standardized. Although Pioneer P32 numerically outperformed Lamuru in terms of daily gain, feed conversion, and efficiency, the differences were not significant, and the increased requirement for supplemental protein and higher seed cost may offset these slight benefits. Thus, both varieties of corn are viable for cultivation in rice fields during the dry season as ruminant feed.

Study Limitation

This study was limited by a relatively small sample size (10 goats), which may have reduced the statistical power to detect subtle differences in treatment effects. Additionally, only two corn-plant silage varieties were evaluated under a specific agroecological and seasonal condition, which may limit generalizability across different environments or management systems. Future research with larger populations, longer feeding durations, and inclusion of additional silage hybrids or alternative feed formulations is recommended to validate and expand upon these findings.

Conclusion

In conclusion, corn-plant silages from Lamuru and Pioneer P32 varieties have similar effects on feed consumption, nutrient digestibility, rumen fermentation, and production performance in Kacang goats. Despite some numerical advantages in ADG and feed efficiency observed with Pioneer P32, these were not statistically significant and came with higher input costs. Therefore, both varieties are suitable for silage production and utilization in goat feeding systems, particularly in dry-season rice fields.

Recommendation

It is recommended that farmers and feed producers in similar agroclimatic zones consider both Lamuru and Pioneer P32 as viable options for silage-based feeding strategies. Selection can be guided by local seed availability, cost considerations, and access to protein supplements. For broader application, further studies involving different ruminant species, extended feeding durations, and evaluation of economic returns are suggested to refine feeding recommendations.

DECLARATIONS

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Author's Contribution: Nurul Purnomo: Designed the study, conducted the experiments, performed the laboratory analyses, data collection and analysis, drafted the manuscript. Asmuddin Natsir: Designed the study, supervised and coordinated the experimental work, data analysis, and drafted the manuscript. Ismartoyo: Designed and supervised the study, data analysis, and drafted the manuscript. Ambo Ako: Designed and supervised the study, data analysis, and drafted the manuscript. All authors critically revised the manuscript and approved the final version.

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