ORIGINAL RESEARCH ARTICLE

Current Research on Biosciences and Biotechnology **5** (2) 2024 17-21

Current Research on Biosciences and Biotechnology

www.crbb-journal.com

Evaluating complete silage for goat feeding in Gorontalo, Indonesia

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ABSTRACT

Forage shortages and inconsistent quality in developing countries pose significant challenges to the small ruminant sector. Feeding ruminants with conserved forages is crucial to address this issue and ensure successful ruminant management in developing countries. The use of sorghum crops mixed with grasses as fermentation feed has gained thought because of its high protein efficiency, relatively high digestible energy, and total digestible nutrients. Therefore, this study aimed to determine feed intake, nutrient digestibility, and growth performance in Gorontalo local goats fed complete silage with varying levels of mixed concentrations of sorghum straw with grasses. Sixteen male Gorontalo local goats were preferred from the local area and randomly divided into four groups using a completely randomized design (CRD). Over 84 days, four different complete silage diets (T1, T2, T3, and T4) were given to goats. The goats' daily nutrient intake, digestibility, and growth performance were analyzed. The T1 diet consisted of 30% grass and 60% sorghum straw, the T2 diet included 20% grass and 70% sorghum straw, the T3 diet contained 10% grass and 60% sorghum straw, and the T4 diet had no grass and 90% sorghum straw. The study found that the dry matter intake (DMI) of goats ranged from 330.2 to 335.1 g/day, approximately 3% of their body weight. The digestibility values of dry matter, crude protein, crude fat, neutral detergent fiber, acid detergent fiber, and energy decreased as the amount of sorghum straw in the silage rations increased. The average daily gain (ADG) (gr/day) in T1, T2, T3, and T4 was affected, with T1 showing the highest ADG (43.2) and T4 showing the lowest (40.3). The Feed Conversion Ratio (FCR) value was also influenced, with T1 and T2 showing the best FCR (7.8 and 7.7) and T3 showing the worst (8.2). Based on these findings, it is recommended to limit the amount of sorghum straw to 60%-70% in complete silage for local goats in Gorontalo, especially in tropical areas where goats are common and sorghum is readily available.

Article history:

Received 23 Aug 2023
Revised 27 Feb 2024
Accepted 28 Feb 2024
Available online 29 Feb 2024

Keywords:

Local goat
digestibility
complete silage

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DOI: 10.5614/crbb.2024.5.2/NEHZ10BA

1. Introduction

Asia is home to nearly 60% of the world's goat population. In 2021, Indonesia's goat population is expected to reach 19.2 million, which is good news for millions of households. As per Rachman et al. (2015), goats are highly valued for their meat and milk. The Gorontalo region of Indonesia has a rich history of goat farming and livestock production, which is deeply intertwined with Islamic rituals. This province has enormous potential for increased goat production, thanks to its plentiful natural forage resources, including legumes and grasses, as well as agricultural waste from food crops and plantations such as corn straw. However, using corn straw waste as animal feed poses certain challenges, as the plant's life cycle is only produced once per planting (Ilato and Bahua, 2014). For this reason, it is necessary to introduce alternative food crops like sorghum as animal feed.

Sorghum plants are similar to corn plants as they are used as food and animal feed sources. Sorghum has the advantage of producing multiple life cycles from a single planting, which makes it more efficient in terms of labor and time. Moreover, it generates more waste than corn, which can be used as sorghum straw for animal feed. Sorghum straw is nutritionally rich, with 10.8% water, 6.7% ash, 8.8% crude protein, 1.2% crude fat, 27.8% crude fiber, and total digestible nutrients (Malisetty et al., 2014). Although 49.8% of the sorghum plant is harvested during the flowering phase, its efficiency and nutritional content make it an ideal crop for development in Gorontalo Province.

Long-term efforts to enhance the goat production in Gorontalo Province have been unsuccessful, despite various policies and programs launched for this purpose by the central and local governments (Ilham et al., 2016). In reality, local farmers have not been able to use and optimize potential existing feed resources, even though improved management and feed resource use increase goat productivity, thus improving the welfare of farmers. Besides, although increased goat production is faced with various other

problems, the primary obstacle remains the traditional livestock management practices used in the region. Moreover, breeders who conduct traditional goat farming activities have not considered optimizing their livestock production. Therefore, the lack of management and technology applications in its cultivation system, including in feed management, making it challenging to increase livestock productivity, traditionally characterizes goat farming. Nevertheless, feed management is essential in the livestock business because feeds have the highest production costs at 60%–70% (Thornton, 2010). As a result, it is impossible to increase output without good feed management. Thus, introducing feed processing and preservation technologies, such as sorghum straw silage technologies, is necessary.

In this study, we fed Gorontalo local goats silage containing different amounts of sorghum straw to test what effect these different levels have on various parameters. Our goal was that this information would help develop improved feed-based management systems from sorghum plant waste for goat livestock in the Gorontalo Province, Indonesia.

2. Materials and methods

2.1. Preparation of complete silage

Sorghum cultivation took place at the Farm Research facility within the Faculty of Agriculture at the State University of Gorontalo, located in Indonesia. It was harvested when it reached maturity, which took approximately 90 days. The harvested sorghum was then cut into small pieces of 2-4 cm using a chaff cutter machine. After this, the sorghum straw, along with grass, millet, corn, and molasses, were mixed and compacted in a pit silo. The silo was securely sealed with plastic covers and held in place with sandbags to ensure it was completely waterproof and airtight. The complete silage was then left sealed in the pit silo for anaerobic fermentation to occur. It was stored for 21 days and not exposed to sunlight. After 21 days of storage, the complete silage was ready to be used as feed for goats.

Table 1. Complete silage formulation

Feed	T1	T2	T3	T4
Grass (%)	30	20	10	0
Sorghum (%)	60	70	80	90
Millets (%)	5	5	5	5
Corn (%)	3	3	3	3
Molasses (%)	1	1	1	1
Premix (ultra-mineral) *(%)	1	1	1	1

a. *Ultra-mineral composition is calcium carbonate 500 g, flour phosphate 150 g, manganese sulfate 1.25 g, potassium iodide 250 g, copper sulfate 0.7 g, sodium chloride 50 g, Iron sulfate 2 g, zinc oxide 1 g, and magnesium sulfate 60 g.

b. T1: 30% grass + 60% sorghum straw, T2: 20% grass + 70% sorghum straw, T3: 10% grass + 80% sorghum straw, and T4: 0% grass + 90% sorghum straw.

2.2. Experimental animals and diet

The research took place at a goat farm located within the Animal Science Department of the Agriculture Faculty at the State University of Gorontalo. Sixteen female goats (local Gorontalo), about eight months old and weighing around 11.1 kg each, were used. These goats were randomly distributed into four treatment groups, with four goats in each group. The four treatment groups were based on different proportions of complete silage with grass and sorghum stalk composition: T1 (30% grass + 60% sorghum stems); T2 (20% grass + 70% sorghum stems), T3 (10% grass + 80% sorghum stems); and T4 (0% grass + 90% sorghum stems). The complete silage formulation is presented in Table 1. The research was conducted for a duration of 84 days in order to investigate the relationship between the quantity of feed ingested and the consequent growth outcomes. At this juncture, the goats were provided with the treatment diets at their own discretion, with feed replenishment occurring twice daily at the specified times of 08:00 and 4:00 pm. Potable water was provided to the goats without charge. Every morning, it was necessary to clean the feed and drinking buckets in order to minimize the risk of contamination from harmful microorganisms such as yeast and mold, as well as to prevent the proliferation of unwanted bacteria that can arise from silage. Each goat's body weight was assessed on a weekly basis prior to the morning feeding in order to analyze the average daily gain (ADG)) and calculated feed conversion ratio (FCR). The chemical composition of the complete silage are shown in Table 2.

2.3. Chemical analysis

The chemical analysis carried out at the Integrated Biotechnology Laboratory, Faculty of Animal Husbandry, Hasanuddin University, Makassar, Indonesia; was aimed at determining the optimal levels of dry matter (DM), organic matter (OM), crude protein (CP), fat, crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF), and energy. The AOAC (1990) method was utilized for this purpose, while the levels of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were examined by adhering to the guidelines provided in Goering and Van Soest (1970).

Table 2. Chemical composition of the complete silage

Parameters	T1	T2	T3	T4
DM (%)	87.0	86.7	86.4	86.0
Ash (%)	14.3	14.5	14.8	15.0
OM (%)	83.5	83.2	82.8	82.4
CP (%)	12.6	12.5	12.4	12.3
Fat (%)	3.1	2.9	2.8	2.9
CF (%)	19.3	19.7	20.0	20.7
ADF (%)	28.4	28.5	32.8	33.8
NDF (%)	44.2	45.8	47.3	49.6
Energy of brute (kkal/kg)	3467.0	3484.0	3552.0	3600.1

DM = dry matter, OM = organic matter, CP = crude protein, CF = crude fiber, ADF = acid detergent fiber, NDF = neutral detergent fiber.

2.4. Statistical analysis

The data was analyzed using SPSS software (version 27, SPSS Inc, Chicago, USA) through one-way analysis of variance (ANOVA). To compare mean values, Duncan's Multiple Range Test (DMRT) was used. If the p-value was less than 0.05, the differences were considered significant.

3. Results and discussion

3.1. Dry matter intake and nutrient digestibility of ration in Gorontalo local goats

The average dry matter intake (DMI) and nutrient digestibility of complete silage rations with different local male Gorontalo goat levels is shown in Table 3. The results of the study presented in Table 3 indicate that the dry matter intake for each complete silage treatment is as follows: T1 at 335.1 g/day, T2 at 333.3 g/day, T3 at 330.2 g/day, and T4 at 330.8 g/day. The analysis of variance revealed that the complete silage treatments exhibited statistically significant differences ($p < 0.05$) in the DMI variable.

The DMI value is about 3% of their body weight goats. This DMI was the same as Kearl (1982), who reported that the DM ratio

needed was 3%–4% of its live weight. According to Devendra and Burns (1983), local goats in the tropics should have a daily DMI in the range of 1.8% to 3.8% of their body weight when they are fed as fully as possible.

Table 3. The average dry matter intake and nutrient digestibility of complete silage rations with local Gorontalo goat.

Variable	T1	T2	T3	T4	SEM
Consume:					
Dry matter intake (gr/day)	335.1[a]	333.3[b]	330.2[d]	330.8[d]	12.1
Digestibility:					
DM (%)	81.5[a]	80.3[b]	78.8[c]	77.9[d]	1.1
OM (%)	82.8[a]	81.4[b]	80.0[c]	79.3[d]	2.3
CP (%)	83.0[a]	82.2[a]	80.9[c]	80.1[c]	2.1
Fat (%)	79.6[a]	78.1[b]	76.5[c]	75.0[d]	1.1
CF (%)	67.8[a]	66.0[b]	64.1[c]	62.0[d]	1.5
NDF (%)	68.7[a]	66.7[b]	64.5[c]	62.2[d]	2.2
ADF (%)	65.9[a]	62.5[b]	59.2[c]	56.0[d]	1.4
Energy (%)	84.1[a]	83.5[b]	82.7[c]	82.0[c]	2.3

Mean values in the same row with the same letter superscript are not statistically different ($p < 0.05$).

The type and quality of feed given to goats have a significant impact on their DMI. In a recent study, all treatments were provided with complete silage consisting of grass and sorghum stems in varying concentrations. The goats' response to the feed provided was not uniform and it resulted in different additional DMI levels, as shown in Table 3. When goats are given feed of varying quality, their response to it is also different. The physical and chemical quality of the feed can affect goat consumption (Marhamah et al., 2019). Good quality feed, with desirable aroma, taste, and texture, has a high palatability that can stimulate goats to increase their consumption. As a result, the nutrient intake obtained by goats for body tissue synthesis also increases. Nutrient content, especially protein and energy, significantly affects palatability. According to Budisatria et al. (2014), factors such as ration quality and the energy required by goats affect goat consumption.

The digestibility of DM, OM, CP, Fat, CF, NDF, ADF and energy of Gorontalo local goats on complete silage T1 was 81.5%; 82.8%; 83.0%; 79.6%; 67.8%; 68.7%; 65.9% and 84.1%; T2 was 80. 3%; 81.4%; 82.2%; 78.1%; 66.0%; 66.7%; 62.5% and 83.5%; T3 by 78.8%; 80.0%; 80.9%; 76.5%; 64.1%; 64.5%; 59.2% and 82.7%; T4 by 77.9%; 79.3%; 80.1%; 75.0%; 62.0%; 62.2%; 56.0% and 82.0%. There were statistically different ($p < 0.05$) in the digestibility of DM, OM, CP, Fat, CF, NDF, ADF, and energy among the four treatments.

The DM digestibility percentage in a recent study ranged from 77.9 to 81.5, with OM digestibility falling within the same range. This level of digestibility is optimal for meeting the nutritional needs of goats. However, the complete feed used in the study had an average crude fiber content of up to 20%, which is relatively high and can inhibit the activity of rumen microbes, thus making it challenging to digest the feed consumed. According to Wijayanti et al. (2012), a high concentration of crude fiber in goat feed results in reduced digestibility because the high fiber content can make the cell wall thicker, which makes it challenging for the microbes in the rumen to penetrate and degrade it.

In this study, the digestibility of CP was analyzed in goats treated with different types of silage. It was found that goats treated with complete silage T1 and T2 had a higher CP digestibility percentage of 83.0 and 82.2, respectively, compared to goats treated with T3 and T4, which had a CP digestibility of 80.9 and 80.1, respectively. This suggests that the activity of protease and kinase (PK) digestion in goats treated with T1 and T2 was more optimal than in those treated with T3 and T4. It is believed that the higher rumen microbial activity in female goats helps in digesting CP in the complete feed they receive. In comparison to Yulianti et al. (2019), the CP digestibility percentage obtained in this study was higher, ranging from 69.8% to 72.0% in male PE goats were provided with fermented feed consisting of tofu pulp and palm kernel meal.

The highest Fat, NDF and ADF digestibilities were observed at T1 and T2 of complete silage diet. This is due to the fact that the silage contains elevated levels of fermentable carbohydrates which subsequently enhance its digestibility as well as nutrients utilized by the animals as well as being associated with grasses that are rich in moisture content. Furthermore, feeding fresh natural grass: decreased methane production in the rumen, increased DMI and a lower proportion of methane in the gas. The identical outcomes occur when equivalent ratios of native grass and sorghum are utilized make a complete sorghum which 60% sorghum straw replace 90-100% alone. It is theorized that a decrease in the material being fermented in the rumen may result in more potentially fermentable material passing to the lower gut. Here, the digestion of this material may lead to an increase in amino acids and precursors of glucose at metabolic sites. This condition same with report research from Preston et al. (2021). The digestibility of both DM and OM exhibited a linear increase ($p < 0.05$) consistent with findings reported by Browne et al. (2005) with the incorporation of corn silage into a grass silage diet. Cavalcante et al. (2004) stated there no notable variance in the digestibility of DM, OM, CP and NDF in steers when they were fed higher amounts of corn silage alongside Tifton-85 hay. However, the highest digestibility of NDF was noted when 60% sorghum straw was included in the diets as part of complete silage. Hunt et al. (1988) reported that the highest beneficial impact was noted when alfalfa hay was included at rate of 25 % in diets containing wheat straw, compared to varying levels substitution (0, 25, 50 and 75 %). Chizzotti et al., (2005) also noted an improvement in the digestibility of DM, OM, CP and NDF following the incorporation of sorghum silage into the grass silage. Likewise, Juniper et al. (2005) and Vranic et al. (2008) informed that the addition of corn silage to grass silage led to either linear or quadratic reactions in the total gastrointestinal tract digestibility.

3.2. Gorontalo local goat growth performance

In this study, the use of different levels of sorghum straw in the silage rations had significant effect ($p < 0.05$) on the initial weight, final weight, average daily gain (ADG), or feed conversion ratio (FCR) of the percentages provided (Table 4).

Table 4. The average initial weight, final weight, ADG, and FCR in local Gorontalo goats with fed the complete silage rations.

Variable	T1	T2	T3	T4	SEM
Initial body weight (gr)	11075[d]	11150[b]	11175[a]	11125[c]	234
Final body weight (gr)	14100[b]	14200[a]	14025[c]	13950[d]	312
Average daily gain (ADG) (gr/day)	43.2[a]	43.5[a]	40.7[b]	40.3[b]	1.2
Feed conversion ratio (FCR) (%)	7.8[b]	7.7[b]	8.2[a]	8.3[a]	0.8

Means on the same row with the same letter superscript are not statistically different ($p < 0.05$).

ADG increased linearly with inclusion levels sorghum straw in complete silage and the highest was observed in 70% (43.5 g/day) and the lowest was 90% (40.3 g/ day). It is possible that the goats preferred the taste of the natural grass over the sorghum. The size of the chopped sorghum pieces may have also acted a deterrent, given their relatively large dimensions. The designed function of the chopping machine for processing fresh forages was found to be inadequate in properly handling the tough outer rind of the sorghum. As a result, pieces of stalk with a thickness of 2 to 3 cm

were produced. It was evident that the findings indicated that the fresh foliage demonstrated superior growth and feed conversion rates in comparison to the dried form when provided as part of basal diets consisting of Gamba grass and sugar cane. This results same with report research from Kounnavongsa et al. (2010). Another, ADG results in this study were higher than the ADG of kacang goats traditionally kept in the lowlands of the Bone Bolango Regency, Gorontalo Province (40 gr/day), but lower than those of kacang goats traditionally kept in the temperate plains of the Bone Bolango Regency, Gorontalo Province (60 g/day) (Sayuti et al., 2018). This difference is deemed due to differences in feed, as kacang goats kept in the temperate plains of the Bone Bolango Regency consume various legumes (Leguminosae) with higher protein levels. The high crude fiber levels in sorghum straw silage rations also caused this difference.

In contrast, Browne et al. (2004) stated that the inclusion of a high proportion of corn silage in the basal diet of grass silage had a detrimental impact on the voluntary intake and growth performance of goat. This was attributed to the build-up of fermentation acid, which may have hindered the functioning of cellulolytic bacteria in the rumen. According to Salam (2009), diets containing high levels of energy have the potential to increase microbial protein synthesis by promoting the coordination of available energy and ammonia nitrogen in the rumen. This, in turn, can contribute to improved nutrient digestibility and increased BW gain.

The Table 4 in this study shows that the average FCR values of the four treatments were relatively different. This means that Gorontalo local goats that were fed with T1 and T2 had similar abilities to efficiently utilize the feed consumed to meet their basic needs or production needs. Although the difference is not significant, the feed conversion values of T1 and T2 tend to be lower than T3 and T4. The reason behind this is that T1 and T2 feeds are generally more effective in converting ration nutrients into meat. As a result, goat growth is faster than goats treated with T3 and T4 feeds. It is worth noting that the FCR value in this study is better than the report of Munawaroh et al. (2015), with FCR ranging from 10.00±3.96 - 13.14±2.87 in Bligon goats given fermented complete feed. In a study conducted by Tahuk and Bira in 2022, Kacang goats were provided with complete feed which resulted in FCR values ranging from 8.56±2.36 to 9.47±2.85. The quality of feed given to goats has a significant impact on their FCR. When Gorontalo local goats are given high-quality feed, their ADG increases, leading to better FCR values. If the feed quality is good, goats require less feed to gain one unit of body weight compared to poor-quality feed.

4. Conclusion

The parameters measured were daily nutrient intake, digestibility, and growth performance. Data analysis showed that complete silage with up to 60% and 70% sorghum straw have a significant effect on DMI, ration nutritional digestibility, ADG, and FCR for local goat Gorontalo diet, especially in tropical areas where goats are common and sorghum is readily available.

Acknowledgements

The authors want to thank Masayuki Sakakibara, Professor of Ehime University, for providing a cooperation grant. This study received funding from Project No.14200102 of the Research Institute for Humanity and Nature (RIHN), which is a constituent member of member of the National Institutes for the Humanities (NIHU).

Conflict of interest

We confirm that there are no conflicts of interest involving any financial organizations related to the matters discussed in the manuscript.

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