Response of Goats to Complete Feed Incorporating Sorghum Forage Silage and *Indigofera sp,* Silage

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Abstract. This study aimed to assess the response of goats to complete feed formulations containing sorghum forage silage and *Indigofera* sp. silage, with the goal of determining the most effective ration composition. The study was arranged in a Completely Randomized Design (CRD) with four treatments and five replications, using 20 local male goats aged nine months. Each goat was housed individually in a 1x1 m pen equipped with a feeding trough. The dietary treatments were: R0: 100% sorghum silage (control) R1: 60% sorghum forage silage + 30% *Indigofera* sp. forage silage + concentrate (1% of body weight); R2: 50% sorghum forage silage + 40% *Indigofera* sp. forage silage + concentrate (1% of body weight) and R3: 40% sorghum forage silage + 50% *Indigofera* sp. forage silage + concentrate (1% of body weight). Parameters measured included dry matter intake (DMI), daily weight gain (DWG), and blood metabolic profile. Analysis of variance revealed that the inclusion of sorghum forage silage and *Indigofera* sp. silage in complete feed significantly affected ($P < 0.01$) DMI. Post hoc analysis indicated that R3 produced significantly higher ($P < 0.01$) DMI compared with R0, R1, and R2. Treatment R2 was significantly higher ($P < 0.05$) than R1, and R1 was significantly higher ($P < 0.01$) than R0. The highest DMI was observed in R3. The feed treatments also had a significant effect ($P < 0.05$) on DWG. R3 yielded the highest DWG, which was significantly greater ($P < 0.01$) than R0, R1, and R2. R2 was significantly higher ($P < 0.05$) than R1, and R1 was significantly higher ($P < 0.05$) than R0. In addition, the dietary treatments significantly influenced ($P < 0.05$) the blood metabolic status of goats. Overall, the R3 formulation comprising 40% sorghum forage silage, 50% *Indigofera* sp. forage silage, and concentrate at 1% of body weight resulted in the most favourable outcomes for goat performance.

Keywords: goat response, complete feed, sorghum forage silage, *Indigofera* sp. Silage

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1 Introduction

Goats are important livestock commodity in Indonesia, contributing significantly to national meat production. Demand for goat meat remains consistently high, particularly during routine consumption periods and religious events such as *qurban* [1].

Sorghum (*Sorghum bicolor*) is a promising crop for wider cultivation in Indonesia due to its resilience to drought and waterlogging, adaptability to marginal soils, and resistance to pests and diseases [2]. The nitrogen-fee extract (NFE) content in 100% dry matter of hybrid sorghum varieties—20, 12FS9006, 13FB7001, and 12S49001—has been reported at 53.28%, 52.90%, 53.54% and 57.49%, respectively [3]. On average, one hectare of sorghum produces 2.62 tons of dry straw, with 86% dry matter in its aerial biomass. Sorghum straw contains 8.9% ash (DM), 4.4% crude protein (DM), 1.6% crude fat (DM), 32.3% crude fiber (DM), and 52.8% NFE (DM) [4].

Indigofera sp., a high-protein forage legume comparable to alfalfa, contains 28-31% crude protein along with essential minerals such as calcium, phosphorus, magnesium and zinc. It is characterized by low tannin content and high beta-carotene levels [5]. Combining *Pennisetum purpuerum* cv. Mott (60%) with *Indigofera* sp. (40%) has been shown to optimize goat performance [6]. As a legume, *Indigofera* sp. typically contains 24.42-31.05% crude protein [7]. Complete feed is a nutritionally balanced ration formulated to meet the needs of specific livestock species and physiological stages. It serves as the sole source of nutrition—excluding water—supporting both maintenance and production.

To harness the nutritional potential of sorghum and *Indigofera,* silage-making technology can be employed. Silage production is an effective preservation method for ensuring feed availability during dry seasons, favored for its low cost, use of local materials and simple processing. Additives are often incorporated during ensiling to enhance quality [8].. Silage utilization has been shown to help overcome seasonal feed shortages [9]..

This study aims to evaluate the effects of complete feed based on sorghum silage and *Indigofera* sp. silage on feed intake, daily weight gain (DWG) and metabolic blood profiled in goats.

2 Materials and methods

2.1 Study site and duration

The research was carried out over a two-month period in Paniki Satu Village and at the Laboratory of the Faculty of Animal Science, Sam Ratulangi University. Twenty local male goats, approximately nine months old, were used in the study. Each goat was kept in an individual pen measuring 1x1 m, equipped with a feed through.

2.2 Experimental design

The experiment evaluated two forage sources—*Sorghum bicolor* and *Indigofera sp*. —in combination with rice bran as an additive. Four dietary treatments, each replicated five times, were formulated as follows:

- R0: 100% sorghum silage (control)
- R1: 60% sorghum silage + 30% *Indigofera* silage + concentrate (1% on body weight)
- R2: 50% sorghum silage + 40% *Indigofera* silage + concentrate (1% on body weight)

- R3: 40% sorghum silage + 50% *Indigofera* silage + concentrate (1% on body weight)

Table 1. Composition of concentrate feed.[10]

Ingredients	**Percentage (%)**
Rice bran	70
Coconut cake	20
Fish meal	9
Bone meal	0.5
Mnerals	0.5
Total	**100**

Table 2. Nutrient composition of sorghum.

Nutrient	**Percentage (%)**
Dry matter	22.13
Crude protein	10.19
Crude fiber	32.35
Crude fat	3.23
Ash	6.58
Nitrogen-free extract	48.37

Table 3. Nutrient composition of *Indigofera*.

Nutrient	**Percentage (%)**
Dry matter	24.89
Crude protein	24.67
Crude fiber	20.20
Crude fat	3.23
Ash	11.32

2.3 Research procedures

2.3.1 Preparation of sorghum and indigofera silage

Fresh forage is chopped into 2-3 cm pieced using a feed chopper, weighed, and adjusted to a moisture content of approximately 70%. Rice bran is then added at 5% of the fresh forage weight as a preservative. The mixture is thoroughly combined and packed tightly into 100-kg plastic drum silos to achieve anaerobic conditions, then sealed with plastic and securely tied. The silos are stored at room temperature for 21 days. After fermentation, the silage is removed, aerated and prepared for incorporation into complete feed ration.

2.3.2 Preparation and feeding of complete diets

Aerated silage is mixed with concentrate according to the dietary treatments. Feed is provided based on the dry matter requirement of the goats, equivalent to 1% of body weight.

2.4 Data collection

Body weights are measured using digital "Soni" scale (capacity 1,000 kg; accuracy 0.5 kg). Feed offered and feed refusals are weighed daily.

Measured variables

1. Daily weight gain (DWG)

$$WG = \frac{B-A}{L} \quad (1)$$

Where:
B = final body weight
A = initial body weight
L = length of experimental period

2. Feed intake (g/head/day)

$$Feed\ intake = Feed\ offered - feed\ refused \quad (2)$$

3. Blood metabolic profile
Includes mineral concentrations (Ca, Mg, P, K, Na, Cl) measured from 2 cc blood samples withdrawn via the jugular vein. Samples are stored under refrigeration until analysis, which is conducted using reagent kits and spectrophotometry.

2.5 Data analysis

The data will be evaluated using a Completely Randomized Design (CRD) comprising four treatments with five replications. Analysis of covariance will be conducted, and if significant differences are observed, Duncan's multiple range test will be performed in accordance with the method described [11].

3 Results and discussion

Table 4. Effect of complete feed based on sorghum silage and *Indigofera* sp. Silage on DMI and DWG

Parameter	Treatment			
	R0	R1	R2	R3
DMI (g/head/day)	400.20[d]	530.25[c]	620.40[b]	675.40[a]
DWG (g/head/day)	40.10[d]	60.50[c]	80.20[b]	105.20[a]

Note: different xsuperscripts in the same row indicate a significant difference ($p<0.05$)

The average dry matter intake (DMI) of the rations in this study ranged from 400.20 to 675.40 g/head/day. Analysis of variance demonstrated that supplementation with complete rations formulated from sorghum silage and *Indigofera* sp. silage exerted a highly significant effect on DMI ($p<0.01$). Post-hoc comparisons revealed that treatment R3 yielded a significantly higher DMI ($p<0.01$) compared to all other treatments (R0, R1 and R2). Additionally, R2 was significantly higher than R1 ($p<0.05$), and R1 exceeded R0 ($p<0.01$). The greatest DMI was recorded in R3. The enhanced feed intake observed in this treatment is likely attributable to goats' preference for the physical and sensory attributes of the feed—namely texture, aroma, taste, and temperature—which collectively influenced consumption levels.

The inclusion of sorghum and *Indigofera* in goats' diets offers complementary nutritional benefits. Sorghum serves primarily as energy source, while *Indigofera* provides a rich source of protein, together forming a balanced ration capable of improving both weight gain and feed conversion efficiency.

The average daily weight gain (DWG) recorded in the present study ranged from 41.10 to 105.20 g/head/day, exceeding the values reported [12, who observed ADGs of 51.83-57.00 g/head/day in goats receiving a basal diet supplemented with *Indigofera.* Variance analysis indicated that complete rations based on sorghum silage and *Indigofera* silage significantly influenced DWG ($p<0.05$). The synergistic combination of these two components enhanced DWG, particularly when supplemented with additional *Indigofera* silage and concentrate feed.

Post-hoc testing confirmed that R3 achieved a significantly higher DWG ($p<0.01$) than R0, R1 and R2. Furthermore, R2 exceeded R1 ($p<0.05$), and R1 surpassed R0 ($p<0.05$). The highest DWG in R3 reflects the treatment's superior capacity for converting ingested nutrients into body mass. The finding aligns with [13] who emphasized that body weight gain is a direct indicator of animal's efficiency in transforming dietary nutrients into muscle tissue.

Maintaining an appropriate nutritional balance among sorghum, *Indigofera* sp. and other supplemental feed components is essential to ensure adequate nutrient intake. With proper formulation, farmers can optimize the utilization of these feed resources to enhance goat productivity and overall growth performance.

Table 5. Effect of complete feed based on sorghum silage and *Indigofera* sp silage on the blood mineral status of goats.

Parameter	Treatment				Normal Range (Olmedo Juarez et al., 2012)
	R0	R1	R2	R3	
Mg (mg/dL)	4.20[c]	6.30[b]	6.45[b]	9.70[a]	2.95
Na (mmol/L)	90.25[c]	135[b]	150[b]	190.[a]	322
Cl (mmol/L)	78.40[c]	118[b]	110[b]	185[a]	200
K (mmol/L)	1.10[c]	3.29[b]	3.50[b]	7.86[a]	17.31
Ca (mg/dL)	3.09[c]	8.15[b]	9.40[b]	14.20[a]	7.81

Note: different xsuperscripts in the same row indicate a significant difference ($p<0.05$)

Dietary supplementation with complete feed formulated from sorghum silage and *Indigofera* sp. silage produced clear effects on blood mineral profiles in goats. Analysis of variance indicated significant treatment differences ($p<0.05$), highlighting the influence of diet composition on mineral metabolism. Goats receiving the R3 ration showed notably higher mineral concentrations than those on R0, R1 or R2, suggesting improved mineral bioavailability and utilization with this formulation. While R2 and R1 did not differ significantly ($p>0.05$), the higher values in R1 compared with R0 ($p<0.05$) indicate that even moderate inclusion of *Indigofera sp.* silage can yield measurable benefits.

Measured mineral concentrations—Ca: 3.09-14.20 mg/dL, Mg: 4.20-9.70 mg/dL; Na: 90.25-190 mmol/L, Cl: 78.40-185 mmol/L, and K: 1.10-7.86 mmol/L—revealed both advantageous and limiting aspects of the tested diets. Calcium and magnesiu levels in several treatments exceeded reference values reported [14]. (Ca: 7.8 mg/dL; Mg: 2.95 mg/dL), potentially supporting skeletal health, neuromuscular activity, and enzyme function. In contrast, sodium, potassium, and chloride levels were consistently below their lower normal limits (Na: 322 mmol/L; K: 17.31 mmol/L; Cl: 200 mmol/L), possibly due to the naturally low electrolyte content of tropical forages, nutrient losses during silage fermentation, or ruminal osmotic adjustments leading to increased excretion.

Such deficiencies in Na, K, and CL may carry physiological consequences, given their central roles in osmotic regulation, acid-base balance, and nerve conduction. Prolonged inadequacies could impair feed intake, growth and water balance. While the R3 diet enhanced certain mineral fractions, strategic supplementation—particularly of sodium and potassium—appears necessary to achieve optimal electrolyte balance and metabolic health in goats maintained on high-forage, silage-based rations.

4 Conclusion

The findings of this study indicate that the R3 treatment—comprising 40% sorghum forage silage, 50% *Indigofera sp.* forage silage, and concentrate at 1% of body weight—yielded the most favorable performance outcomes in goats.

The authors express their gratitude to the Rector of Sam Ratulangi University for providing funding through RTUU_K1 in the 2025 Fiscal Year.

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