

Substituting star grass with corn fodder in Bali Heifer Diets: Impact on intake, digestibility, nitrogen balance, and blood profile

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Abstract. Jalaludin, Nikolaus TT, Sabat DM, Setyani NMP. 2025. *Substituting star grass with corn fodder in Bali Heifer Diets: Impact on intake, digestibility, nitrogen balance, and blood profile.* *Asian J Agric* 9: 881-888. This study aimed to evaluate the substitution of Star Grass Silage (SGS) with hydroponic Corn Fodder (CF) in the diets of Bali heifers, with a focus on feed intake, nutrient digestibility, nitrogen retention, and blood profile parameters. Hydroponic corn fodder was assessed as a sustainable alternative to star grass silage for Bali heifers, which are typically raised in dry tropical regions characterized by seasonal forage scarcity. Previous studies on the use of corn fodder have predominantly focused on dairy cattle, buffaloes, or goats; therefore, this study provides novel information on Bali heifers in terms of intake, digestibility, nitrogen retention, and blood profiles to determine the optimal substitution level. The experiment employed a 4 × 4 Latin square design with four dietary treatments, consisting of the replacement of SGS with CF at levels of 0%, 20%, 40%, and 60%. The results showed that CF substitution significantly affected ($P < 0.05$) nitrogen intake and nitrogen retention, with the highest values observed at the 20% CF substitution level, while increasing the substitution to 60% resulted in reduced nitrogen intake and retention. In contrast, CF substitution had no significant effect ($P > 0.05$) on dry matter, organic matter, and crude protein intake, nutrient digestibility, or blood profile parameters. It was concluded that hydroponic corn fodder can effectively replace star grass silage at substitution levels of 20-40% of the forage portion without impairing nutrient utilization or physiological balance. These findings highlight the potential of hydroponic corn fodder as a forage resource to support the sustainability of Bali cattle production in tropical regions with limited forage availability, particularly during the dry season.

Keywords: Bali cattle heifers, corn fodder, nitrogen retention, star grass

INTRODUCTION

The availability of high-quality forage is a critical factor influencing the productivity of ruminant livestock in tropical regions. In areas such as East Nusa Tenggara (NTT), Indonesia, forage production is highly seasonal, characterized by abundant growth during the rainy season and severe shortages during prolonged dry periods. During the rainy season, tropical grasses generally contain 12-15% Crude Protein (CP) and exhibit digestibility levels of approximately 70%. In contrast, during the dry season, CP content may decline to as low as 3%, while digestibility drops below 50% (Jelantik et al. 2019). These fluctuations markedly affect livestock performance, particularly Bali cattle, the predominant indigenous breed in eastern Indonesia, which plays a crucial role in food security, cultural heritage, and rural livelihoods (Anggraeny et al. 2025).

Among tropical forage species, star grass (*Cynodon nlemfuensis*) is widely recognized for its relatively high biomass yield and superior nutritional quality during the rainy season. Under optimal growing conditions, this species typically contains 14-15% Crude Protein (CP) and more than 60% digestible organic matter (Nurjannah et al. 2021; Picado-Pérez et al. 2024). However, the nutritional quality of star grass deteriorates markedly during the dry season, characterized by a decline in Crude Protein (CP) content to below 3% and an increase in crude fiber concentration, which collectively reduces its palatability

and digestibility. Silage production is commonly adopted as an alternative strategy to overcome forage shortages during the dry season; however, its application is often ineffective among smallholder farmers. According to Anjos et al. (2020), silage production is frequently constrained by poor silo management, fermentation failures, and labor-intensive handling requirements. Therefore, alternative forage sources that are more consistent, sustainable, and efficient are urgently needed.

Hydroponically grown Corn Fodder (CF) has emerged as a promising strategy to alleviate forage shortages in arid and semi-arid regions. Cultivated within a short growth cycle of 7-10 days under controlled hydroponic conditions, this fodder produces green biomass characterized by stable nutritional composition and a higher crude protein content compared to conventionally cultivated corn forage. Typically, hydroponic corn fodder contains 12-14% Crude Protein (CP), a lower fiber fraction, and superior digestibility (Naik et al. 2016; Lim et al. 2022). Additionally, the production requires minimal land area, water resources, and external inputs. Studies on dairy cattle, goats, and buffaloes have demonstrated that partially replacing conventional feed with hydroponically grown corn fodder enhances nutrient intake, improves digestibility, and positively influences overall animal performance (Kide et al. 2015; Castillo et al. 2023). In addition, the production of hydroponic fodder is environmentally efficient, as it requires less water and land compared to conventional

forage cultivation (Jemimah et al. 2018; Hassen and Dawid 2022). Despite its promising potential, the application of hydroponically grown corn fodder in Bali cattle, particularly during the heifer stage, remains insufficiently investigated. The development of heifer cattle represents a critical phase, as it involves the transition toward reproductive maturity. Therefore, the quality of feed intake and nutrient metabolism play essential roles in supporting growth, particularly the development of reproductive organs. The nutrients consumed contribute to nitrogen balance or nitrogen retention that aligns with normal physiological conditions of the animals (age, body weight, and hormonal status), thereby reflecting an optimal nutritional status to support growth and reproductive readiness (Astuti et al. 2021). Overall, this phase highlights that optimal growth and adequate nutrient supply are key determinants of subsequent reproductive performance and lifetime productivity.

Although previous investigations have predominantly focused on dairy cattle (Naik et al. 2016, 2017), buffalo calves (Castillo et al. 2023), and goats (Lim et al. 2022), empirical evidence remains scarce regarding the effects of hydroponically grown corn fodder on nutrient utilization, nitrogen balance, and blood metabolites in Bali heifers. Understanding these effects is of critical importance, as nitrogen retention serves as a key indicator of protein utilization efficiency (Shen et al. 2023), while blood metabolites, such as glucose, urea, and total protein, serve as important markers of an animal's nutritional and physiological status (Umar et al. 2015). This study addresses a significant research gap by evaluating the substitution of star grass silage with hydroponically grown corn fodder in the diet of Bali heifers. The novelty of this investigation lies in: (i) the implementation of hydroponic corn fodder as a sustainable forage alternative, particularly suited to Bali heifers maintained under dry tropical conditions; (ii) the comprehensive integration of feed intake, nutrient digestibility, nitrogen retention, and blood metabolite analyses to obtain a holistic assessment of animal responses; and (iii) the identification of the optimal substitution level that maximizes nutrient utilization efficiency while maintaining physiological homeostasis.

Based on these considerations, the present study aimed to evaluate the effects of substituting star grass silage with hydroponically grown corn fodder at varying inclusion levels on feed intake, nutrient digestibility, nitrogen retention, and hematological parameters in Bali heifers. It was hypothesized that partial substitution would sustain feed intake and digestibility while improving nitrogen retention and blood biochemical profiles, thereby providing a practical and sustainable feeding strategy for Bali cattle production within dry tropical production systems.

MATERIALS AND METHODS

Ethical clearance

The study received ethical approval under the code No/Ref: 122/1.KT/KEPPKP/VI/2023. Animal welfare monitoring was conducted at the beginning of the

experiment and during blood sampling. All experimental animals were handled humanely, with efforts made to minimize pain and stress. The study was carried out at the field laboratory of the Integrated Dryland Technical Implementation Unit, Universitas Nusa Cendana, Kupang, Indonesia.

Research location and animals used

This research was carried out in the field laboratory of the Integrated Dry Land of Technical Implementation Unit, Universitas Nusa Cendana, Kupang, using 4 Bali cattle heifers, with body weights ranging from 99.5 to 152 kg. All experimental animals were clinically healthy and exhibited no prior history of metabolic or infectious disorders. Before the commencement of the trial, each animal was administered an anthelmintic treatment and vaccinated in accordance with established veterinary health protocols. The feed given consisted of star grass silage, corn fodder, and concentrate in the mixture with corn flour, rice bran, fish meal, and mineral premix. The Bali cattle heifers to be studied were placed in a metabolic cage equipped with a container for food and water.

Feeding treatment programed

The study was conducted using a Latin Square Design (LSD), with 4 treatments and 4 periods of repetition (Fazaeli et al. 2021). Each experimental period spanned 21 days, comprising 14 days of dietary adaptation and 7 days of data collection. The experimental design was employed to minimize individual animal variability and to control for potential period effects throughout the study. Dry Matter Intake (DMI) is generally estimated at approximately 2.5-3.0% of body weight, depending on feed quality (NRC 2016). In the present study, feed was offered at 3% of body weight on a dry matter basis, based on the consideration that feed intake increases with body weight and represents a practical estimate of the daily feed requirement, particularly for young cattle. The feeding ratio was 70% forage (star grass silage and corn fodder) and 30% concentrate. Corn fodder was given as a substitute for star grass silage at the levels of 20%, 40% and 60%. The treatments tested were as follows: (i) FJ0: 70% star grass silage + 30% concentrate, (ii) FJ20: 50% star grass silage + 20% corn fodder + 30% concentrate, (iii) FJ40: 30% star grass silage + 40% corn fodder + 30% concentrate, (iv) FJ60: 10% star grass silage + 60% corn fodder + 30% concentrate. The results of the nutritional analysis of feed ingredients and experimental rations are presented in Table 1.

Preparation of experimental diets

Making star grass silage begins by chopping star grass with a chopper machine. The chopped materials were made wilted, and put into a silo, compacted, and then tightly closed to create an anaerobic atmosphere. The silage was stored for 21 days. After that, the silage was opened and allowed to air in order to be ready for feed to livestock. Making corn fodder is carried out by soaking corn seeds for 12 hours in order to stimulate germination. The corn seeds were sprinkled evenly on the seedling tray made form of a modified PVC box gutter to avoid waterlogging. The

watering was done in the morning, afternoon, and evening to keep the seeds moist. On the 7th day after germination, the corn fodder was harvested and then washed and given to livestock according to treatment. Concentrate feed was composed of 55% corn flour, 40% rice bran, 4% fish flour, and 1% premix.

Rations and drinking water were provided *ad libitum* to all experimental animals, and daily feed intake was recorded. Each experimental period lasted 15 days, comprising a 10-day adaptation phase to the experimental diet followed by a 5-day total collection period for fecal and urine sampling. These procedures were conducted to assess nutrient intake, digestibility, and nitrogen retention. The parameters observed were calculated using the following formulas by Shen et al. (2023).

Nitrogen intake

Daily nitrogen (N) intake was determined by multiplying the feed intake by the crude protein content of the diet and dividing the result by the protein conversion factor of 6.25. The nitrogen intake value was calculated using the following formula:

$$\text{N consumption (g/h/d)} = \frac{\text{Feed intake (g DM/h/d)} \times \text{CP diet (\%)}}{6.25}$$

Fecal Nitrogen Excretion refers to the portion of nitrogen that is not digested from the consumed feed and is excreted through the anus as feces. It was calculated using the following formula:

$$\text{Fecal Nitrogen Excretion (g/h/d)} = \text{Fecal DM (g/h/d)} \times \text{Fecal Nitrogen Content (\%)}$$

Urinary Nitrogen Excretion represents the amount of nitrogen derived from protein metabolism in the animal's body that is not utilized and is eliminated through urine. It was calculated using the following formula:

$$\text{Urinary Nitrogen Excretion (g/h/d)} = \text{Urine Volume (mL/h/d)} \times \text{Urine Nitrogen Content (\%)}$$

Nitrogen digestibility

Nitrogen digestibility represents the proportion of nitrogen intake that is digested and absorbed by the animal, reflecting the efficiency of nitrogen utilization from the diet. It was calculated using the following formula:

$$\text{Nitrogen Digestibility (\%)} = \frac{\text{Nitrogen Intake} - \text{Fecal Nitrogen Excretion}}{\text{Nitrogen Intake}} \times 100\%$$

Nitrogen retention

Nitrogen retention represents the amount of nitrogen retained in the body after accounting for losses through feces and urine, indicating the efficiency of nitrogen utilization for growth and maintenance. It was calculated using the following formula:

$$\text{Nitrogen retention (g/h/d)} = \text{Nitrogen intake} - (\text{Fecal nitrogen excretion} + \text{Urinary nitrogen})$$

Blood sample collection and parameters

Blood samples were collected on the 15th day of each period via the jugular vein using a 22 G venoject needle attached to a holder and an Ethylene Diamine Tetraacetic Acid (EDTA) tube. Analyses of glucose and total blood protein were conducted at the Laboratory of Reproductive Biology and Animal Health, Faculty of Animal Husbandry, Marine and Fisheries, Universitas Nusa Cendana. Plasma was separated by centrifugation at 4,000 rpm for 10 minutes or 12,000 rpm for 2 minutes. Measurements of blood glucose and total blood protein concentrations were performed using a Microlab 300 spectrophotometer. Blood glucose and blood urea levels were calculated following the method of Luan et al. (2020) using the following formula:

$$\text{Glucose level (mg/dL)} = \frac{\Delta A \text{ sample}}{\Delta A \text{ standard}} \times 100$$

$$\text{Urea levels (mg/dL)} = \frac{\Delta A \text{ sample}}{\Delta A \text{ standard}} \times 50$$

Total protein

The determination of total protein was conducted using a spectrophotometric method. A monoreagent (reagent mix) was prepared by combining reagent 1 and reagent 2 in a 4:1 ratio. Subsequently, 20 μL of the blood serum sample was placed in a tube and mixed with 1 mL of monoreagent. For the standard solution (100 mg/dL), 20 μL of standard was combined with 1 mL of monoreagent, while for the blank, 20 μL of distilled water was mixed with 1 mL of monoreagent. The mixtures were centrifuged for 2 minutes at 12,000 rpm using a vortex mixer and incubated for 5 minutes at room temperature. Absorbance was measured sequentially (standard, monoreagent, standard, sample) at 540 nm using a Microlab 300 Photometer. The total blood protein concentration was then calculated using the following formula:

Table 1. Nutritional composition of experimental ration ingredients and treatments

Item	DM (%)	OM (%)	CP (%)	CFa (%)	CFi (%)	CHO (%)	NDF (%)
Feed ingredients							
Star Silage Grass	48.05	89.73	9.15	3.61	36.01	76.97	40.96
Corn Fodder	17.80	97.26	12.00	5.44	9.77	79.83	70.05
Concentrate	89.86	87.80	9.53	4.86	18.10	73.41	55.41
Treatment							
FJ0	60.60	89.72	9.15	3.61	36.01	76.97	70.05
FJ20	54.55	91.23	9.72	4.00	30.76	77.53	46.78
FJ40	48.50	92.45	10.29	4.33	25.51	73.11	52.60
FJ60	42.45	94.23	10.86	4.71	20.26	78.68	58.42

Note: FJ0: 100% star grass silage; FJ20: 80% star grass silage + 20% corn fodder; FJ40: 60% star grass silage + 40% corn fodder; FJ60: 40% star grass silage + 60% corn fodder; DM: Dry Matter; OM: Organic Matter; CP: Crude Protein; Cfa: Crude Fat; Cfi: Crude Fiber; CHO: Carbohidrat; NDF: Non-Digestible Fiber

$$\text{Total Protein} = \frac{\Delta \text{ Sample absorbance}}{\Delta \text{ standard absorbance}} \times \text{standard concentration}$$

Data analysis

The collected data were subjected to statistical analysis using the General Linear Model (GLM) procedure in SPSS version 25 (IBM Corp., Armonk, NY, USA) employing Analysis of Variance (ANOVA). When significant treatment effects were detected, mean separation was conducted using Duncan's Multiple Range Test (DMRT) to identify specific differences among treatments.

RESULTS AND DISCUSSION

The feed intake and nitrogen digestibility

Based on the experimental findings, the substitution of Star Grass Silage (SGS) with Corn Fodder (CF) at inclusion levels of 20%, 40%, and 60% did not exert a significant effect ($P > 0.05$) on the intake and digestibility of Dry Matter (DM), Organic Matter (OM), or Crude Protein (CP). As presented in Table 2, there was a discernible trend of decreasing nutrient intake and digestibility beginning at the 40% substitution level. Nevertheless, CF was readily accepted by Bali heifers, indicating that its inclusion did not compromise feed palatability or the efficiency of nutrient utilization.

Nitrogen balance

The research data and statistical analysis presented in Table 3 indicate that the treatments had a significant effect ($P < 0.05$) on nitrogen intake and nitrogen retention. Substitution of Star Grass Silage (SGS) with Corn Fodder (CF) at the 20% level resulted in the highest values,

followed by the 40% and 60% substitution levels. The substitution also had a significant effect ($P < 0.05$) on reducing urinary nitrogen excretion but had no significant effect ($P > 0.05$) on fecal nitrogen excretion. Moreover, the mean values of nitrogen intake, fecal nitrogen, urinary nitrogen, and nitrogen retention are also illustrated graphically (Figure 1). The reduction in urinary nitrogen excretion contributed to an increase in nitrogen retention.

Figure 1 shows that nitrogen intake in the FJ20 substitution treatment was the highest, followed by FJ0, FJ40, and FJ60. A similar trend was observed for nitrogen retention. However, urinary nitrogen excretion was lowest in the FJ20 treatment, followed by FJ40, FJ60, and was highest in FJ0. In contrast, fecal nitrogen excretion among treatments with SGS substituted by CF remained relatively consistent.

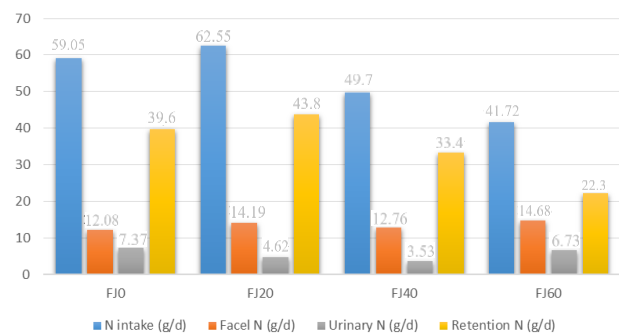


Figure 1. The treatments significantly affected ($P < 0.05$) nitrogen intake and nitrogen retention, whereas no significant effects ($P > 0.05$) were observed on fecal nitrogen and urinary nitrogen

Table 2. Effect of substituting star grass silage with hydroponic corn fodder on feed intake and digestibility in Bali heifers

Parameter	FJ0	FJ20	FJ40	FJ60	SEM	P-Value
DMI (kg)	3.99±1.68 ^a	4.20±1.26 ^a	3.29±1.26 ^a	2.71±0.96 ^a	1.850	0.399
OMI (kg)	3.56±1.51 ^a	3.75±1.13 ^a	2.95±1.14 ^a	2.44±0.86 ^a	1.450	0.411
CP Intake (kg)	0.37±0.15 ^a	0.40±0.12 ^a	0.31±0.12 ^a	0.26±0.092 ^a	0.014	0.458
DMD (%)	60.72±22.49 ^a	61.52±9.75 ^a	50.27±18.71 ^a	38.43±9.68 ^a	4.689	0.202
OMD (%)	62.30±21.89 ^a	63.45±9.33 ^a	53.27±17.49 ^a	42.21±9.12 ^a	3.878	0.236
CPD (%)	76.99±11.50 ^a	77.10±4.33 ^a	72.71±9.82 ^a	63.76±7.24 ^a	1.569	0.155

Note: Different superscripts in the same row indicate significant differences ($P < 0.05$); FJ0: 100% star-grass silage; FJ20: 80% star-grass silage + 20% corn feed; FJ40: 60% star grass silage + 40% corn feed; FJ60: 40% star grass silage + 60% corn feed; DMI: Dry Matter Intake; OMI: Organic Matter Intake; CPI: Crude Protein Intake; DMD: Dry Matter Digestibility; OMD: Organic Matter Digestibility; CPD: Crude Protein Digestibility

Table 3. Effect of substituting star grass silage with hydroponic corn fodder on nitrogen balance in Bali heifers

Parameter	FJ0	FJ20	FJ40	FJ60	SEM	P-Value
NI (g/d)	59.05±24.76 ^{ab}	62.55±18.68 ^{ab}	49.70±18.90 ^b	41.72±14.56 ^a	1.641	0.09
FNE (g/d)	12.08±4.16 ^a	14.19±4.07 ^a	12.76±3.80 ^a	14.68±3.56 ^a	0.448	0.099
UN (g/d)	7.37±3.39 ^a	4.62±1.90 ^{ab}	3.53±0.60 ^b	6.73±2.09 ^{ab}	0.339	0.340
NR (g/d)	39.6±19.3 ^a	43.8±15.26 ^a	33.4±17.3 ^{ab}	22.3±13.6 ^b	1.638	0.005

Note: Different superscripts in the same row indicate significant differences ($P < 0.05$); FJ0: 100% star grass silage; FJ20: 80% star grass silage + 20% corn feed; FJ40: 60% star grass silage + 40% corn feed; FJ60: 40% star grass silage + 60% corn feed; NI: Nitrogen Intake; FNE: Fecal Nitrogen Excretion; UN: Urinary Nitrogen; NR: Nitrogen Retention

Blood profile

Substitution of SGS with CF at all inclusion levels did not result in significant differences ($P > 0.05$) in any of the blood parameters of the experimental animals. As shown in Table 4, the lowest Blood Urea Nitrogen (BUN) concentration (39.45 mg/dL) was observed at the FJ60 substitution level, whereas the highest (40.12 mg/dL) was recorded at the FJ0 level. Blood glucose concentration ranged from 81.91 mg/dL at the FJ0 level to 83.81 mg/dL at the FJ60 level. Similarly, Total Plasma Protein (TPP) concentration was lowest (6.95 g/dL) at the FJ0, FJ20, and FJ60 substitution levels, and highest (7.05 g/dL) at the FJ40 level. Overall, all blood parameters measured in this study were within the normal physiological range.

Discussion

Feed intake and nutrient digestibility

The results of this study indicated that substitution of SGS with CF had no significant effect on the intake and digestibility of Dry Matter (DM), Organic Matter (OM), and Crude Protein (CP). As presented in Table 2, a similar pattern was observed across all parameters, where substitution of SGS with CF led to a slight increase at the FJ20 level compared with the control (without substitution), followed by a decrease at the 40% and 60% substitution levels. Statistically, the absence of differences in nutrient intake and digestibility suggests that feed palatability was not affected by the substitution of SGS with CF or by the physical characteristics of CF. These findings are consistent with previous studies on dairy cattle (Naik et al. 2017) and buffalo calves (Castillo et al. 2023), which examined the substitution of conventional forages with hydroponic maize fodder. Similarly, Banamtuan et al. (2020) reported that replacing field grass silage with hydroponic maize fodder at 35% and 70% inclusion levels did not significantly affect feed intake or crude fiber digestibility in weaned Ongole crossbred calves. Comparable results were also observed by Puay et al. (2023) and Nomleni et al. (2024), who evaluated the substitution of Kume grass silage with hydroponic maize fodder at 35% and 50% levels in Kacang goats. Feed intake and nutrient digestibility are strongly influenced by palatability, feed processing form, nutrient composition, and both animal and environmental conditions.

Accordingly, the present findings demonstrate that the experimental diets, whether consisting entirely of star grass silage or partially replaced with hydroponic maize fodder at 20%, 40%, or 60% had comparable palatability, resulting in no observable differences in feed intake or digestibility. The high moisture content, softer texture, and relatively low fiber fraction of hydroponic maize fodder likely contributed to its similar level of preference. However, the high water content of hydroponic maize fodder (82.20%) may also induce early satiety in animals, thereby acting as a limiting factor for dry matter intake (Fazaeli et al. 2021).

The digestibility of Dry Matter (DM), Organic Matter (OM), and Crude Protein (CP) is presented in Table 2. Substitution of SGS with CF at various inclusion levels had no significant effect ($P > 0.05$), indicating that the nutrient composition and fermentability of CF were comparable to those of SGS. Hydroponic fodder generally contains lower levels of Neutral Detergent Fiber (NDF) and lignin, which supports microbial activity and enhances ruminal degradation (Kide et al. 2015; Lim et al. 2022). Therefore, although CF had a lower DM content, its high nutrient availability was sufficient to maintain balanced digestion. This stability is essential to ensure a consistent nutrient supply for the growth and development of heifers, which ultimately determines their reproductive potential and future productivity. The NDF contents of maize fodder increase significantly with advancing harvest age (Cantón-Castillo et al. 2020; Gacutan Jr et al. 2021). This increase is attributed to the maturation of maize shoots, fiber accumulation, water stress, and changes in cell wall composition. Consequently, the DM content of maize fodder tends to decrease after the sixth day of production. Maize fodder also contains phytic acid, which may inhibit digestive enzyme activity. Rajkumar et al. (2018) reported that replacing up to 50% of starter concentrate with maize fodder in calf diets did not significantly affect crude protein or crude fiber intake but proved effective without any adverse impact on growth performance or nutrient utilization. Similarly, nutrient digestibility was not significantly influenced by diets containing maize fodder. Cantón-Castillo et al. (2020) reported that hydroponic maize fodder can serve as an excellent forage source for sheep when incorporated at 40% of the diet to replace commercial feed.

Table 4. Effect of substituting star grass silage with hydroponic corn fodder on the blood profile of Bali cattle heifers

Parameter	FJ0	FJ20	FJ40	FJ60	SEM	P-Value
BUN (mg/dL)	40.12±1.19 ^a	39.72±1.64 ^a	40.06±1.01 ^a	39.45±1.44 ^a	0.391	0.722
Glucose (mg/dL)	81.91±2.78 ^a	82.10±5.55 ^a	82.66±7.59 ^a	83.81±5.84 ^a	2.917	0.685
TPP (g/dL)	6.95±0.10 ^a	6.95±0.06 ^a	7.05±0.19 ^a	6.95±0.19 ^a	0.010	0.638
Hb (g/dL)	10.53±0.31 ^a	10.32±0.28 ^a	10.24±0.44 ^a	10.27±0.25 ^a	0.530	0.692
PCV (%)	30.12±0.91 ^a	30.94±0.84 ^a	30.72±1.34 ^a	30.79±0.75 ^a	0.470	0.692
Erythrocytes (10 ⁶ /mL)	10.82±0.71 ^a	10.91±0.71 ^a	11.12±0.62 ^a	11.11±0.44 ^a	0.132	0.712
Leukocytes (10 ³ /mL)	11.73±0.86 ^a	12.96±1.42 ^a	11.96±0.90 ^a	12.41±1.09 ^a	1.171	0.304

Note: The same superscript in the same row indicates a non-significant difference ($P > 0.05$), FJ0: 100% star grass silage; FJ20: 80% star grass silage + 20% corn feed; FJ40: 60% star grass silage + 40% corn feed; FJ60: 40% star grass silage + 60% corn feed; BUN: Blood Urea Nitrogen; TPP: Total Plasma Protein; Hb: Hemoglobin; PCV: Packed Cell Volume

Nitrogen balance

The mean values of nitrogen intake, fecal nitrogen, urinary nitrogen, and nitrogen retention, along with the results of statistical analysis, are presented in Table 3. Statistical analysis revealed that substitution of SGS with CF had a significant effect on nitrogen intake, urinary nitrogen, and nitrogen retention, but no significant effect on fecal nitrogen. The average nitrogen retention obtained from each treatment showed a decreasing trend with increasing levels of SGS replacement by CF. The highest nitrogen retention value was 43.8%, whereas the lowest was 22.3%; however, nitrogen retention remained positive because the amount of nitrogen excreted was lower than the amount consumed. Nitrogen retention serves as an indicator of the efficiency of protein utilization by livestock and is influenced by feed quality, nitrogen intake, and nitrogen losses through feces and urine. As illustrated in Figure 1, a significant decrease in nitrogen retention was observed at the 40% and 60% substitution levels of SGS with CF. This decline was likely due to increased nitrogen excretion in feces and urine, suggesting that dietary protein was not utilized efficiently by rumen microbes. In addition, an imbalance between energy and protein supply may have led to excessive protein catabolism to compensate for the energy deficit. Comparable findings were reported by Arif et al. (2023), who observed that buffalo calves fed diets containing maize fodder exhibited higher nitrogen balance compared with those not receiving maize fodder; however, inclusion levels of 60% and 80% did not result in significant differences.

This finding indicates that the most pronounced effect of replacing SGS with CF was observed on nitrogen balance, where nitrogen intake and nitrogen retention peaked at the 20% substitution level, reaching 62.55 g/h and 43.80 g/h, respectively, along with a decrease in urinary nitrogen excretion. This suggests improved synchronization between the supply of fermentable energy and available nitrogen for rumen microbes, thereby enhancing microbial protein synthesis and reducing nitrogen loss through urine. Physiologically, CF provides readily fermentable carbohydrates and relatively fast-degrading protein sources, which at moderate inclusion levels promote optimal nitrogen utilization efficiency. The decline in nitrogen retention observed at the higher CF substitution level (60%) is likely attributable to two factors: (i) dilution of dry matter intake due to the high moisture content of maize fodder, which alters the ratio of fermentable energy to protein; and (ii) reduced intake of effective fiber, which affects rumen retention time and the Volatile Fatty Acid (VFA) profile, ultimately decreasing rumen microbial efficiency (Shen et al. 2023). Therefore, hydroponic fodder should be strategically used as livestock feed in situations where conventional feed resources are scarce or cannot be cultivated due to adverse climatic conditions (Naik et al. 2016).

Blood profile

Statistical analysis showed that the substitution of Star Grass Silage (SGS) with hydroponic corn fodder at levels of 20%, 40%, and 60% had no significant effect ($P > 0.05$)

on Blood Urea Nitrogen (BUN) and blood glucose concentrations. The relatively similar BUN values across treatments indicate efficient nitrogen metabolism, as nitrogen intake and excretion remained balanced. This condition suggests that the protein quality of hydroponic corn fodder and star grass silage was comparable and that the protein levels in the experimental diets met the physiological requirements of Bali heifers. Meanwhile, blood glucose concentrations ranging from 81.91 to 83.81 mg/dL indicate that the substitution of hydroponic corn fodder did not disrupt blood energy homeostasis. This finding is consistent with the results reported by Tahuk et al. (2018) who observed that Bali cattle fed diets rich in readily digestible carbohydrates maintained stable blood glucose levels within the physiological range of 70-90 mg/dL, with no indication of metabolic stress.

The substitution of Star Grass Silage (SGS) with hydroponic corn fodder also had no significant effect ($P > 0.05$) on other blood profile parameters, including Total Plasma Protein (TPP), Hemoglobin (Hb), Packed Cell Volume (PCV), erythrocyte count, and leukocyte count. This finding is consistent with Arif et al. (2023), who reported that calves fed hydroponic corn fodder replacing up to 40% of the basal diet (rice straw and wheat straw) showed no alterations in blood metabolite parameters, including glucose and hemoglobin. These results indicate that Bali heifers are physiologically capable of adapting their digestive system to changes in forage type. According to Sofyan et al. (2020), metabolic status and blood profiles are important indicators of the physiological, nutritional, and pathological conditions of animals. In line with this, Astuti et al. (2021) noted that changes in metabolic status and blood profiles are influenced by multiple factors, including genetics, age, sex, physiological status, dietary nutrition, and management practices. Similarly, in the present study, substitution of SGS silage with hydroponic corn fodder at levels up to 60% did not induce physiological disturbances or metabolic stress in the experimental animals.

Livestock production systems in tropical regions face significant challenges related to the availability and quality of forages due to highly contrasting seasonal conditions. During the rainy season, pastures produce an excess of biomass that cannot be fully utilized by livestock, whereas in the dry season, dry matter intake declines sharply (Sloat et al. 2018). Approximately 80-85% of total forage biomass is produced during the rainy season, underscoring the need to optimize its utilization through preservation technologies to address feed shortages during the dry period (Anjos et al. 2020). One commonly applied preservation method is silage production. However, inefficiencies in tropical forage production, combined with losses during harvesting and ensiling, have limited the effectiveness of tropical grass silage utilization. Producing high-quality silage depends on several key factors, including dry matter content, the availability of soluble carbohydrates, and low buffering capacity (da Silva et al. 2017).

Hydroponic maize fodder represents a promising alternative forage source for ruminants, as it can be cultivated year-round without seasonal limitations and with

minimal land and water requirements. Hydroponic feed production relies solely on aqueous media in a controlled environment and allows for short growth cycles of 7-13 days (Wahyono et al. 2018). From a practical perspective, this innovation is highly relevant to smallholder farmers in arid tropical regions such as East Nusa Tenggara (NTT). Hydroponic maize fodder can be produced continuously throughout the year with limited resources (Hassen and Dawid 2022), thus addressing forage scarcity during the dry season. Moreover, by improving protein utilization efficiency at optimal substitution levels (20-40%), the use of CF has the potential to reduce feed costs and promote more sustainable growth of Bali cattle. From a practical standpoint, the production of maize fodder offers a viable strategy to mitigate forage shortages during the dry season, although it should be aligned with overall maize production capacity to ensure long-term sustainability. From a practical perspective, the production of hydroponic corn fodder offers a viable strategy to mitigate forage shortages during the dry season, although it requires alignment with overall corn production capacity to ensure long-term sustainability.

The findings of this study demonstrate that CF can replace SGS up to 40% without adverse effects on feed intake, digestibility, or blood parameters, while enhancing nitrogen retention at 20-40% substitution levels. This study represents the first investigation into CF substitution in Bali heifers, a critical developmental stage that determines future reproductive performance and lifetime productivity.

In conclusion, hydroponic corn fodder represents a practical and sustainable alternative feed for Bali cattle production systems in tropical dryland areas, particularly in addressing forage shortages during the dry season. Substitution of star grass silage with hydroponic corn fodder in the diets of Bali heifers at levels up to 60% did not affect feed intake, nutrient digestibility, or blood metabolic profiles; however, it resulted in reduced nitrogen retention. Therefore, a substitution level of 20-40% is recommended.

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