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The Effect of Complete Feed on Dry Matter Intake (DMI), Crude Protein Intake (CPI) and Metabolite Status in Female Fat-Tail Sheep

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Abstract: This study aimed to evaluate dry matter intake (DMI), crude protein intake (CPI), and metabolite status, including blood urea nitrogen (BUN), glucose, and total protein, in female fat-tail sheep fed a complete feed. The study was conducted from July to September 2022 at a farmer group managed by PT Juara Agroniaga in Kanor Village, Bojonegoro Regency, East Java, Indonesia. A total of 200 female fat-tail sheep aged 1–2.5 years with an average body weight of 27 ± 4.65 kg were reared in 10 group pens (20 animals per pen). Feed intake was recorded daily for six weeks, and blood samples were collected to determine BUN, glucose, and total protein. Data were analyzed descriptively. The results showed that DMI and CPI were 71.00 ± 5.88 and 6.83 ± 0.57 g/kg $BW^{0.75}$, respectively. Metabolite status showed BUN of 25.15 ± 6.94 mg/dL, glucose of 83.83 ± 14.43 mg/dL, and total protein of 4.54 ± 2.58 g/dL. The complete feed was consumed at an acceptable level under farmer conditions, as reflected by the observed DMI. however, the high fiber content and relatively low crude protein level may have contributed to suboptimal metabolite profiles. In conclusion, the nutritional quality of the complete feed influenced nutrient intake and was reflected in the metabolite status of female fat-tail sheep.

Keywords: Blood urea nitrogen; Crude protein intake; Dry matter intake; Female fat-tail sheep; Glucose; Total protein

Introduction

Fat-tail sheep are one of the important local small ruminants in Indonesia and have considerable potential as meat-producing animals. Their productivity is influenced not only by genetic factors but also by environmental factors, particularly feeding management and dietary quality. Among these factors, feed plays a central role because it directly determines nutrient intake, nutrient utilization, and physiological status, which ultimately affect animal performance and health.

The use of complete feed has become increasingly relevant in sheep production systems because it allows feed ingredients to be formulated into a single ration that is practical, nutritionally balanced, and easier to distribute under field conditions. Complete feed can improve feeding efficiency, reduce feed selection by animals, and optimize the utilization of locally available agricultural by-products. However, the nutritional adequacy of a complete feed must be evaluated carefully, especially in relation to nutrient intake and physiological responses of the animals.

Assessment of feed quality should not only be based on nutrient composition but also on actual feed consumption and metabolite status. Dry matter intake (DMI) and crude protein intake (CPI) are important indicators of nutrient consumption, whereas blood metabolites such as blood urea nitrogen (BUN), glucose, and total protein can provide information on protein

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metabolism, energy status, and general physiological condition. BUN reflects nitrogen utilization and protein metabolism, glucose indicates energy availability, and total protein may reflect the adequacy of protein supply and hydration status.

Although complete feed is widely applied in practical sheep farming, information regarding its effect on nutrient intake and metabolite status in female fat-tail sheep under farmer conditions remains limited. Therefore, this study was conducted to evaluate DMI, CPI, and metabolite status (BUN, glucose, and total protein) in female fat-tail sheep fed a complete feed under field conditions. The findings are expected to provide practical information for improving complete feed formulation and nutritional management in small ruminant production system.

Method

Location and Time

This study was conducted from July to September 2022 at a farmer group managed by PT Juara Agroniaga, Kanor Village, Bojonegoro Regency, East Java, Indonesia. Analysis of blood metabolites, including blood urea nitrogen (BUN), glucose, and total protein, was carried out at Satwa Sehat Clinic. Analysis of feed chemical composition was conducted at the Animal Feed Laboratory, Livestock and Fishery Service of Blitar Regency.

Materials

The animals used in this study were 200 female fat-tail sheep aged 1–2.5 years with an average body weight of 27 ± 4.65 kg. The animals were housed in 10 group pens, with 20 sheep in each pen. All animals were fed a complete feed composed of molasses, coffee husk, corn tumpi, kale straw, pollard waste, copra meal, soybean straw, palm kernel meal, peanut shell, and minerals. The chemical composition of the complete feed is presented in Table 1.

Tabel 1. Chemical composition of complete feed

Chemical Composition	%
DM	89.55
OM	91.67
CP	9.75
EE	1.53
CF	31.52
NDF	69.59
TDN	57.47

Research Procedure

This study used an observational case study approach under farmer group conditions. The research procedure consisted of three main stages. First, the complete feed was provided to the animals according to the farmer group feeding management system. Second, feed intake was observed for six weeks by recording the amount of feed offered and feed refusals daily. Samples of feed offered and refusals were collected every day, pooled weekly, and composited for laboratory analysis. Third, blood samples were collected from the animals and analyzed for BUN, glucose, and total protein to evaluate metabolite status.

Variables Measured

The variables observed in this study were: Dry matter intake (DMI), expressed as g/kg $BW^{0.75}$; Crude protein intake (CPI), expressed as g/kg $BW^{0.75}$; Blood urea nitrogen (BUN), expressed as mg/dL; Blood glucose, expressed as mg/dL; Total blood protein, expressed as g/dL.

Data Analysis

The data obtained were tabulated using Microsoft Excel then analyzed using descriptive analysis.

Result and Discussion

Dry Matter Intake (DMI) and Crude Protein Intake (CPI)

The values of dry matter intake (DMI) and crude protein intake (CPI) of female fat-tail sheep fed the complete feed are presented in Table 2. The average DMI and CPI were 71.00 ± 5.88 and 6.83 ± 0.57 g/kg $BW^{0.75}$, respectively. The results indicate that an increase in dry matter intake was followed by an increase in crude protein intake because crude protein is a component of dry matter consumed by the animals.

Tabel 2. Dry Matter Intake (DMI) and Crude Protein Intake (CPI) in female fat-tail sheep

Flock	DMI (g/ kg $BB^{0.75}$)	CPI (g/ kg $BB^{0.75}$)
F1	76.42	7.35
F2	75.97	7.31
F3	72.77	7.00
F4	63.32	6.09
F5	72.60	6.98
F6	73.92	7.11
F7	68.31	6.57
F8	59.34	5.71
F9	77.35	7.44
F10	70.04	6.74
Average	71.00	6.83
sd	5.88	0.57

Nutrient intake in sheep is closely related to the nutrient composition of the diet, particularly the balance between energy, protein, and fiber. Beyene (2020) reported that different concentrate mixtures significantly affected total dry matter intake and total

crude protein intake in lambs, with the highest intake obtained when energy and protein sources were combined in the ration. This finding supports the present study, in which crude protein intake increased in line with dry matter intake because crude protein is part of the dry matter consumed by the animals. However, the crude protein content of the complete feed in this study was relatively low (9.75%), while NDF was relatively high (69.59%), which may have limited nutrient intake and utilization. A high fiber fraction can increase rumen fill and reduce the rate of passage, thereby limiting voluntary feed intake. Therefore, the moderate DMI and relatively low CPI observed in this study may be associated with the high fiber content and limited protein concentration of the complete feed.

The observed DMI value in this study was within the range reported in previous studies on small ruminants, indicating that the complete feed was still acceptable under farmer conditions. However, the CPI value tended to be relatively low, which was likely associated with the low crude protein content of the complete feed, namely 9.75%. Adequate crude protein intake is essential to support rumen microbial growth, nutrient digestion, nitrogen utilization, and protein metabolism. Rochana et al. (2020) reported that the balance between dietary protein and energy affected dry matter intake, body weight gain, and feed conversion in Garut sheep, indicating that protein and energy synchronization is important for improving ration efficiency. Similarly, Wang et al. (2022) showed that different dietary protein levels altered ruminal metabolites, particularly amino acids, carbohydrates, and organic acids, although the major bacterial communities were relatively stable. These findings support the interpretation that low CPI in the present study may reflect suboptimal protein supply for rumen microbial activity and nutrient utilization.

In addition to crude protein concentration, the high fiber content of the feed may also have influenced intake. The complete feed used in this study contained 69.59% NDF and 57.47% TDN, indicating a relatively fibrous ration with moderate energy value. High NDF concentration may increase rumen fill, prolong retention time, and slow the rate of passage, thereby limiting voluntary feed intake. This condition may explain the moderate DMI observed in the present study. Rochana et al. (2020) stated that feed degradation rate in the rumen is closely related to rumen retention time; feeds with higher digestibility tend to leave the rumen faster and stimulate higher feed intake. Therefore, the relatively high NDF content in the present complete feed may have limited the opportunity for greater DMI.

Metabolite Status (BUN, Glucose, Total Protein)

The metabolite status of female fat-tail sheep fed the complete feed is presented in Table 3. The average values of BUN, glucose, and total protein were 25.15 ± 6.94 mg/dL, 83.83 ± 14.43 mg/dL, and 4.54 ± 2.58 g/dL, respectively.

Table 3. Metabolite status of female fat-tail sheep

Flock	BUN (mg/dl)	Glucose (mg/dl)	Total Protein (g/dl)
F1	18.37	78.33	4.66
F2	17.63	60.33	4.42
F3	39.93	87.33	2.71
F4	33.20	88.00	4.55
F5	25.47	81.00	1.51
F6	20.20	107.33	6.23
F7	26.10	103.00	1.64
F8	23.67	88.33	9.47
F9	20.77	67.33	7.45
F10	26.13	77.33	2.79
Average	25.15	83.83	4.54
sd	6.94	14.43	2.57

Compared with the normal reference values reported by Meyer et al. (1992), the average BUN and glucose values in this study tended to be slightly higher, whereas the total protein value tended to be lower. The relatively elevated BUN value, despite the modest crude protein content of the diet, may suggest that nitrogen utilization was not fully efficient. This could be related to limited synchronization between rumen-available nitrogen and fermentable energy, variation in protein degradability among feed ingredients, or differences in sampling time. In the present study, the relatively low crude protein content of the feed combined with the high fiber fraction may have reduced the efficiency of nutrient utilization and contributed to variation in nitrogen metabolism.

The relationship between feed quality and intake has also been demonstrated in several studies using alternative feed resources and fermented feeds. Beyene (2020) reported that concentrate mixtures affected total dry matter intake and crude protein intake in lambs, with the highest intake achieved when energy and protein sources were supplied in a balanced combination. Aliyah et al. (2023) showed that supplementation with 25% fermented Moringa leaves decreased dry matter intake but did not alter blood glucose, blood protein, blood urea, albumin, or triglycerides in local male sheep, suggesting that better nutrient quality may maintain metabolic status even when intake decreases. Sujarnoko et al. (2023) also reported that complete feed silage supplemented with tofu by-product did not significantly affect DMI but improved monthly weight gain and feed efficiency, while BUN and glucose remained unaffected. These findings indicate that feed processing, fermentation, and nutrient balance may influence intake and efficiency

differently depending on feed quality and nutrient availability.

The moderate DMI and relatively low CPI in the present study may therefore be related to both nutrient composition and physical characteristics of the feed. Tölü (2025) reported that forage-to-concentrate ratio influenced nutrient intake and blood biochemical traits in lambs and goat kids, although glucose and BUN were relatively stable across different forage-to-concentrate groups. Similarly, Chu et al. (2026) showed that forage physical form, particularly alfalfa hay chop length, affected growth performance and behavior in sheep, indicating that not only nutrient composition but also feed structure can influence feed utilization. These studies strengthen the assumption that complete feed formulation should consider crude protein content, energy density, fiber fraction, and physical characteristics to optimize intake and nutrient utilization.

Compared with normal reference values reported by Meyer et al. (1992), the average BUN and glucose values in this study tended to be slightly higher, whereas total protein tended to be lower. Elevated BUN may indicate that nitrogen metabolism was not fully efficient. BUN is commonly used as an indicator of protein utilization efficiency and is closely associated with energy adequacy. Nurrochman et al. (2023) reported that BUN reflects the efficiency of protein use in metabolism and is correlated with energy status in Garut ewes fed complete feed based on sorghum and Indigofera. When protein degradation in the rumen is not synchronized with available energy, ammonia produced from protein breakdown may not be efficiently incorporated into microbial protein, leading to increased urea formation and elevated BUN.

The relatively high BUN value in the present study may also be related to the imbalance between crude protein supply, energy availability, and rumen fermentability. Wang et al. (2022) explained that dietary protein levels can alter ruminal metabolic profiles and nutrient absorption-related metabolites. Higher dietary protein levels increased metabolites related to amino acids, carbohydrates, and organic acids, indicating that protein supply can influence rumen metabolic function. In the present study, although CP concentration was relatively low, the high fiber content and moderate TDN may have reduced the efficiency of ruminal nitrogen utilization, causing nitrogen metabolism to become less optimal.

The role of bioactive compounds and alternative feed ingredients in nitrogen metabolism should also be considered. Al Rharad et al. (2025), in a meta-analysis of dietary tannins in small ruminants, reported that tannins can reduce ruminal NH_3-N and BUN by decreasing protein degradability in the rumen and improving nitrogen utilization efficiency. However, the effect depends on tannin source, level, and animal condition. In the present study, the complete feed contained several agricultural by-products that may contain secondary compounds, but the formulation may not have been sufficient to improve nitrogen efficiency. This supports the need to improve complete feed formulation not only by increasing crude protein but also by balancing rumen degradable protein, energy supply, and possible protein-protecting compounds.

The glucose concentration observed in this study was slightly above the normal range. This may reflect differences in feeding time, physiological status, stress during handling, or availability of glucogenic precursors derived from rumen fermentation. In ruminants, glucose is mainly produced through gluconeogenesis, particularly from propionate produced during ruminal fermentation. Khotijah et al. (2020) reported that blood glucose in sheep reflects energy metabolism and functions as a rapid energy source for vital organs, reproduction, and other physiological activities. Their study also showed that supplementation of 5% vegetable oil did not disturb nutrient intake or blood metabolite profile in ewes, indicating that stable glucose values may reflect maintained physiological condition.

Several studies also support that blood glucose is strongly influenced by ration quality and energy metabolism. Kurniawan et al. (2025) reported that feeding silage to PE goats affected feed consumption and maintained blood metabolite levels, with glucose values varying according to feeding time. The authors explained that changes in glucose concentration may be influenced by carbohydrate digestion and energy metabolism. Similarly, Putri et al. (2022) found that replacing fish meal with Moringa leaf meal in concentrate did not significantly affect blood glucose, urea, cholesterol, or total protein in goats fed mixed silage, suggesting that alternative protein sources can be used without disturbing blood metabolites when nutrient balance is maintained.

The total protein concentration in this study was lower than the normal range, suggesting that protein supply from the complete feed may not have fully met the physiological requirements of female fat-tail sheep. This interpretation is supported by the relatively low CP content of the feed and the low CPI value. Total blood protein reflects protein metabolism, nutrient absorption, hydration status, and general physiological condition. Kurniawan et al. (2025) stated that total protein and albumin are influenced by protein intake, digestive tract condition, and animal health status. A low total protein value may occur when essential amino acid supply is limited or when high-fiber feed reduces ruminal degradation and intestinal nutrient availability.

This finding is also consistent with studies showing that adequate nutrient intake is required to maintain blood and physiological status. Astuti et al. (2022) reported that different flushing management in late-pregnant local thin-tailed ewes did not significantly affect nutrient intake and most hematological profiles, indicating that stable blood profiles may occur when nutrient adequacy is maintained. Kamil (2020) also reported that differences in protein and energy balance did not disturb the hematological status of weaned Garut sheep, suggesting that animals can maintain physiological stability when dietary protein and energy remain within acceptable ranges. In contrast, the lower total protein value in the present study indicates that the complete feed may require improvement to support better protein metabolism.

The use of agro-industrial by-products in complete feed can support sustainability, but their inclusion must be carefully formulated to avoid excessive fiber and nutrient imbalance. Zhao et al. (2025) reported that moderate inclusion of rubber seed cake at 6% improved immune and antioxidant status without negative effects on growth performance and rumen fermentation in Hu sheep, whereas higher levels could negatively affect nutrient digestion and metabolism. Bahrampour et al. (2025) also showed through a dose-response meta-analysis that grape by-products had no significant effect on DMI, ADG, glucose, albumin, triglycerides, or total protein, but affected feed conversion ratio and BUN in a dose-dependent manner. These findings indicate that by-products can be useful feed resources, but their inclusion level must be optimized to maintain digestibility, nitrogen utilization, and metabolic status.

The present complete feed was formulated using several local feed ingredients such as molasses, coffee husk, corn tumpi, kale straw, pollard waste, copra meal, soybean straw, palm kernel meal, peanut shell, and minerals. Such ingredients are useful in practical feeding systems because they are locally available and can reduce feeding costs. However, their nutritional value varies and some ingredients may contribute to high fiber concentration. Ngawit & Farida (2022) emphasized the potential of forage and agricultural resources as animal feed, but also noted that forage availability and nutrient composition are important constraints in livestock production systems. Padang et al. (2023) also reported that durian by-products could be used in goat feed without negative effects on productivity and physiological condition at appropriate levels. Therefore, the practical use of local by-products in complete feed should be accompanied by nutrient evaluation and formulation adjustment.

The interpretation of nutrient intake and metabolite status should also be placed within the broader context of feed supplementation in small ruminants. Murniati and Muchlis (2021) reported that supplementary feeding during pregnancy improved body weight gain in pregnant goats and influenced blood glucose according to breed and gestational stage. Although the present study did not specifically evaluate pregnancy status, this finding supports the concept that nutrient supply from formulated diets may be reflected in body metabolism and blood biochemical indicators.

The use of local and agro-industrial feed resources has been widely promoted as a strategy to improve feed availability and sustainability in ruminant production. Mardiansyah et al. (2025) emphasized that cashew nut shells have potential as alternative sheep feed because of their energy content and bioactive compounds, although processing is required to reduce toxic phenolic compounds. Guelfi et al. (2025) also showed that 5% grape pomace supplementation in sheep was metabolically safe and did not negatively affect meat quality, supporting the value of agro-industrial by-products in sustainable feeding systems. Similarly, Xu et al. (2025) demonstrated that fermented vegetable leaf concentrate improved growth performance, antioxidant capacity, immune response, intestinal morphology, and rumen microbial diversity in sheep. These findings indicate that the complete feed used in the present study could be improved through appropriate processing, particularly fermentation, to increase nutrient quality and utilization.

Fermentation and feed processing may be important strategies for improving high-fiber complete feeds. Sangadji et al. (2023) reported that the use of energy sources such as rice bran, cassava, and sago pulp in dwarf elephant grass silage improved chemical composition, dry matter digestibility, organic matter digestibility, volatile fatty acid concentration, and rumen pH. This supports the assumption that the high NDF content of the present complete feed could be addressed by improving fermentability and digestibility. In a broader applied context, Mastiani et al. (2023) showed that hydroponic-based animal feed production can be used as a practical learning and empowerment medium, indicating that simple feed technologies may also support farmer capacity in feed preparation and utilization.

Feed evaluation should also consider physiological adaptation, environmental conditions, and potential feed contaminants. Yanti et al. (2025) reported that Indonesian local sheep raised at different altitudes showed physiological responses in heart rate, respiratory rate, and body temperature, indicating that environment can influence animal physiological status. Saeed et al. (2025) demonstrated that excessive organic copper supplementation in Awassi lambs increased copper retention and produced histological changes in liver and kidney, highlighting the importance of mineral

balance in complete feed formulation. Hendrawan et al. (2023) further showed that organophosphate insecticide exposure through cattle feed may affect reproductive hormones, indicating that feed safety should be considered in addition to nutrient composition. In wildlife and small ruminant-related management, Apriana et al. (2023) also emphasized that feeding behavior is a dominant daily activity, supporting the relevance of feed availability and feeding management in maintaining animal condition.

From the perspective of production efficiency and sustainability, feed intake and feed conversion traits are important long-term targets in sheep production. Fonseca et al. (2025) reported that the integration of epigenomic and genomic data could be used to predict residual feed intake and feed conversion ratio in dairy sheep, showing that feed efficiency is influenced by both nutritional and biological factors. Irunal et al. (2026) also predicted that diet and longevity influence lifetime methane production and methane intensity in dairy ewes. These studies support the importance of improving complete feed formulation not only to maintain metabolite status but also to enhance feed efficiency and reduce environmental impacts. Saefullah et al. (2024) similarly emphasized that animal welfare-based management, including appropriate nutrition and stress reduction, contributes to reducing greenhouse gas emissions and improving cattle productivity.

Overall, the metabolite profile suggests that the complete feed used in this study was able to maintain basic physiological function but had not yet provided an optimal nutritional balance for female fat-tail sheep. The combination of low crude protein, relatively high NDF, and moderate TDN may have limited crude protein intake, reduced nutrient utilization, and contributed to less favorable BUN and total protein values. Therefore, improvement of complete feed formulation is recommended, particularly by increasing crude protein concentration, improving protein-energy synchronization, reducing excessive fiber fractions, and considering processing technologies such as fermentation or silage. Such improvements are expected to enhance DMI, CPI, rumen microbial activity, nitrogen utilization, and blood metabolite status in female fat-tail sheep.

This study should be interpreted within the context of its observational and descriptive design. Because the animals were group-fed under farmer conditions and no comparison diet was included, the present findings primarily describe the nutritional and metabolite status associated with the tested complete feed rather than establishing direct causal effects. In addition, the wide variation in some blood metabolite values, especially total protein, suggests that individual physiological status, sampling time, and field management conditions may also have influenced the results.

Conclusion

The complete feed provided moderate dry matter intake and crude protein intake in female fat-tail sheep, with average values of 71.00 ± 5.88 and 6.83 ± 0.57 g/kg $BW^{0.75}$, respectively. However, the metabolite profile indicated that BUN and glucose tended to be higher than normal, while total protein tended to be lower. These findings suggest that the nutritional quality of the complete feed, particularly its relatively low crude protein and high fiber content, influenced nutrient intake and was reflected in the metabolite status of the animals. Improvement of complete feed formulation is needed to optimize nutrient utilization and metabolic condition in female fat-tail sheep.

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Author Contributions

Conceptualization, P.H.N., M., and V.M.A.N.; methodology, P.H.N., M.H.N., and I.N.; investigation, project administration, P.H.N. and J.M.A.; formal analysis, funding acquisition, P.H.N. and M.; resources, J.M.A. and M.; data curation, writing original draft preparation, visualization, P.H.N.; writing review and editing, V.M.A.N., M.H.N., M., and I.N.; supervision, M. and V.M.A.N. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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