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RESEARCH ARTICLE
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The Effect of Protein and Energy Ratio on Growth Performance, Nutrient Digestibility, and Blood Metabolite Profile of Pesisir Cattle Calves

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ABSTRACT

This study aims to evaluate the effect of protein and energy ratios in feed on growth performance, nutrient digestibility, and blood metabolite profiles in Pesisir cattle calves. Four calves were used in a Latin square design (4×4) with four treatment combinations: A (CP 12%: TDN 60%), B (CP 14%: TDN 60%), C (CP 12%: TDN 65%), and D (CP 14%: TDN 65%). The parameters observed included feed intake, feed conversion ratio (FCR), daily weight gain (DWG), dry matter digestibility, crude protein digestibility, organic matter digestibility, and blood glucose, urea, and cholesterol levels. The results showed that increasing protein and energy levels improved digestibility and growth performance in calves. Treatment D exhibited the most significant levels of DWG (588g/day), dry matter digestibility (64.61%), organic matter digestibility (67.57%), and crude protein digestibility (79.83%). Treatment D further minimized blood cholesterol and urea levels and boosted plasma glucose. It was concluded that combining the ration with 14% crude protein (CP) and 65% total digestible nutrients (TDN) gave the best performance and metabolic efficiency for Pesisir calves.

Keywords: Pesisir cattle, Protein, TDN, Digestibility, Blood metabolite.

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INTRODUCTION

The Pesisir cattle are one of Indonesia's local livestock germplasms and have high potential to serve as a national source of animal protein. The coastal regions of West Sumatra mainly have this cattle population, which can adapt well to poor-quality feed, a hot climate, and diseases and pests (Hartatik et al., 2018; Yetmaneli et al., 2023; Wu et al., 2024). Nevertheless, cattle production in Pesisir is still not as high as that of crossbred beef cattle, and the very early growth stage, or calfhood, is particularly critical in determining reproductive and production performance in the later phases (Pazla et al., 2024).

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The growth performance of calves is strongly affected by the adequacy of protein and energy in the ration. Protein is essential for building body tissues, whereas energy is needed for metabolic processes and microbial protein synthesis in the rumen (Zain et al., 2023; Zain et al., 2024). An imbalance between protein and energy causes metabolic inefficiency: excess protein without sufficient energy increases nitrogen excretion as urea, while excess energy with low protein reduces microbial protein synthesis and feed digestibility (Moradikor & Zadeh, 2013; Lu et al., 2019; Han et al., 2022; Suriyapha et al., 2022; Moseri et al., 2025).

Prior research has indicated that the protein-to-energy ratio significantly affects feed efficiency and physiological performance in local cattle. Pazla et al. (2024) reported that in Pesisir heifers, a protein ratio of 10% and a TDN of 65% resulted in the highest digestibility and the highest percentage of first estrus. Moreover, during the experiment on pregnant Pesisir cattle, Pazla et al. (2025) reported that increasing the protein content to 12% with 65% TDN improved digestibility and blood metabolic status without excess nitrogen. However, scientific information on the physiological and metabolic responses of Pesisir cattle calves to protein-energy ratios remains minimal, even though this phase is a critical period for tissue growth and the development of a functional digestive system.

Therefore, this experiment was conducted to determine the effects of varying protein-to-energy ratios in the diet on growth performance, nutrient digestibility, and blood metabolite profiles in Pesisir cattle calves. The findings of this study are expected to provide a foundation for formulating balanced rations that support nutrient use efficiency and sustainably increase the productivity of local Indonesian cattle.

Although studies on protein and energy levels in cattle feed have been conducted extensively by previous researchers, research on the optimal balance is still limited to Pesisir cattle calves. The early growth phase is the most important period for tissue development and metabolic efficiency, while previous researchers have primarily focused on young or adult female cattle. Thus, this study aims to evaluate the effects of different protein-to-energy ratios on several components, namely growth performance, nutrient digestion capacity, and blood metabolite profiles, in Pesisir cattle calves. The results of this study are expected to provide a physiological basis for formulating a balanced ration that supports efficient nutrient utilization and sustainable productivity in local cattle under tropical conditions.

MATERIALS & METHODS

Location and Time of Research

The research was conducted at the Animal Husbandry Faculty of Andalas University, Padang. Metabolic pens were used to facilitate more accurate data collection on feed consumption, fecal excretion, and body weight measurements in Pesisir cattle calves. This study was conducted in three stages: adaptation, preliminary, and collection/evaluation. The study lasted for 120 days, including 7 days for the adaptation phase, 18 days for the preliminary phase, and five days for the collection phase per period.

Animal Management and Housing Conditions

During the experiment, all Pesisir cattle calves were placed separately in metabolic pens with adequate space, clean bedding, and good ventilation. The ambient temperature in Padang, West Sumatra, ranged from 26-32°C (tropical conditions). Natural lighting was used, with an average lighting period of 12 hours/day, and no artificial lighting was used at night. Throughout the study, clean drinking water was freely available. Maintenance was carried out under the same management for all calves, with regular pen cleaning and daily health checks. To ensure consistent consumption patterns, forage and concentrate feed were given in the morning and afternoon. During the experiment period, no additional feed or plant promoter was used. These management conditions were applied uniformly across all treatments to minimize the influence of environmental and management factors on the observed responses.

Research Design

This study used a Latin square design. There were feed treatments with protein and energy ratios as shown in Table 1. Four Pesisir cattle calves with an initial weight of 89.25±3.22kg and aged 5-6months were used as research subjects. Each calf was treated based on a predetermined combination of protein and energy ratios.

Table 1: Feed treatment with protein and energy ratios

Nutrition (%)	Treatment			
	A	B	C	D
Protein	12	14	12	14
TDN	60	60	65	65

Note: A (CP 12%: TDN 60%), B (CP 14%: TDN 60%), C (CP 12%: TDN 65%), and D (CP 14%: TDN 65%), TDN (total digestible nutrient), CP (crude protein).

Research Period

This study consisted of three periods: an adaptation period (7 days), a preliminary period (18 days), and a collection period (5 days). During the adaptation period, the cattle were given treatment rations to help them acclimate to the new feed and environment. During this time, the cows' condition was monitored to ensure there was no stress or rejection of the feed. Next, during the 18-day preliminary period, the cattle received the complete treatment ration, and observations of feed consumption and their physical condition were made to serve as baseline data. The five-day collection period involved intensive data collection, including fecal collection, measurement of ration consumption, animal weighing, and blood sampling to analyze metabolic conditions. Feces were collected daily, while body weight was measured at the start and end of the collection period to obtain precise data on changes in body weight. Feces were collected daily, and body weight was measured at the start and end of the collection period to obtain precise data on changes in body weight.

Feed and Ration Composition

The study feed was formulated to meet the protein and energy requirements for each treatment, and the rations consisted of a forage-concentrate mixture. Protein levels of 12% and 14%, and energy levels of 60 and 65% in terms of TDN were targeted. Elephant grass and Indigofera were among the forages used and administered to all treatments in fixed amounts as a source of natural fiber and protein. In the meantime, the protein and energy content of the concentrate component was modified for each treatment. Nutritional content tests were conducted in the lab on all concentrate ingredients to verify that they were suitable for the rations, which differed in their protein and energy ratios from those targeted in the study.

The nutritional composition of the rations and nutrients in the feed were evaluated using the AOAC (2016) and Van Soest et al. (1991) methods at the Ruminant Nutrition Laboratory. The analysis involved measuring organic matter, dry matter, crude protein, fiber, fat, energy content, and fractions (NDF, ADF, cellulose). The nutritional aspects of the feed components, feed composition, and nutritional value of each feed treatment are summarized in Table 2, 3, and 4.

Parameters Observed

The parameters observed in this experiment included several important factors that demonstrated the influence of the protein-to-energy ratio on feeding on the physiological responses and growth performance of Pesisir calves. Feed consumption was determined as the quantity of feed provided minus the daily feed residue and included the consumption of dry matter (DM), organic matter (OM), and crude protein (CP). Consumption data were collected during the observation period to assess the palatability of the ration and the livestock's ability to utilize it. Nutrient digestibility was determined for organic matter, dry matter, and crude protein to evaluate how nutrients could be digested and absorbed by the body. These digestibility values provided an overview of the rumen's nutrient utilization efficiency and fermentation balance.

In addition, daily weight gain (DWG) was also measured to determine calves' growth rate during the study period, which was then used to calculate feed efficiency and feed conversion ratio (FCR) as indicators of how effectively cattle convert feed into body weight. Another physiological parameter observed was the blood metabolite profile, which reflects the metabolic status of cattle. Blood samples were collected from the jugular vein for laboratory analysis of total protein, cholesterol, and glucose. These values were used to assess the metabolic balance between the utilization of protein, fat, and carbohydrates in the body and to identify whether the feed provided supported metabolic efficiency and overall physiological health of the cattle.

Data Collection

Data collection in this study was conducted systematically during the data collection phase to obtain accurate information on the growth performance, digestibility, and metabolic status of Pesisir calves. Feces were collected daily from each cow during the collection period. Each fecal sample was weighed to determine total daily production, and a portion was dried and analyzed for organic matter, dry matter, and undigested crude protein. The data were used to calculate the real digestibility of each nutrient and feed utilization efficiency.

Table 2: Chemical content of feed ingredients

Chemical Content (%)	Corn	Indigofera	Rice corn	Elephant grass	Sago	Palm kernel meal
Dry matter	90.82	87.30	87.50	63.39	68.45	89.76
Organic matter	95.79	89.99	89.44	89.46	99.35	96.66
Ash	4.21	10.01	11.09	11.69	0.65	3.34
Crude protein	9.96	26.82	8.23	9.69	2.56	20.77
Crude fat	4.07	6.96	6.28	1.13	0.45	5.06
Crude fiber	2.51	18.32	10.56	21.76	6.75	15.97
NFE	78.25	35.89	62.83	48.29	89.59	54.86
TDN	72.36	65.07	70.87	57.36	66.20	74.80
ADF	58.62	18.83	48.11	43.78	45.34	39.73
NDF	34.66	25.94	23.08	63.63	65.83	63.58
Hemicellulose	19.70	7.11	11.05	20.06	20.49	23.85
Cellulose	23.96	13.31	25.03	26.85	25.43	25.56
Lignin	7.50	4.54	3.78	5.68	8.46	9.42
Silica	0.70	0.98	2.28	11.25	11.45	4.75

Table 3: Ration composition of treatment

Feedstuff	Treatment			
	A	B	C	D
Elephant grass	21	21	21	21
Indigofera	19	19	19	19
Rice corn	45	36	16	15
Palm kernel meal	3	16	10	18
Corn	2	2	22	24
Sago	8	4	10	1
Minerals	1	1	1	1
Salt	1	1	1	1
Total	100	100	100	100

Note: A (CP 12%: TDN 60%), B (CP 14%: TDN 60%), C (CP 12%: TDN 65%), and D (CP 14%: TDN 65%), TDN (total digestible nutrient), CP (crude protein).

Table 4: Chemical content of treatment rations

Chemical nutrient (%)	Treatment			
	A	B	C	D
Dry matter	50.54	51.22	49.80	50.33
Organic matter	90.90	95.41	92.87	92.68
Ash	11.58	11.02	9.46	9.64
Crude protein	12.93	14.80	12.55	14.07
Crude fat	6.66	6.75	6.01	6.40
Crude fiber	15.87	17.00	14.56	15.18
NFE	57.61	59.09	60.67	57.94
TDN	60.50	60.44	65.55	65.21
ADF	42.41	43.25	43.87	43.66
NDF	38.54	44.73	44.55	44.17
Hemicellulose	15.28	17.39	18.10	18.45
Cellulose	24.71	25.78	24.54	24.53
Lignin	6.87	7.75	8.10	8.20
Silica	6.65	7.06	6.69	6.03

Note: A (CP 12%: TDN 60%), B (CP 14%: TDN 60%), C (CP 12%: TDN 65%), and D (CP 14%: TDN 65%), NFE (nitrogen-free extract), TDN (total digestible nutrient), CP (crude protein).

Weight measurements were taken twice at the start and end of the collection phase to determine daily weight gain (DWG) as a direct indicator of growth efficiency. Meanwhile, blood samples were taken on the final day of the collection phase through the jugular vein using a sterile syringe. Then, blood samples were collected, processed, and analyzed in the laboratory to determine blood levels of total protein, cholesterol, and glucose. These parameters were used to evaluate the livestock's metabolic status and the feasibility of the ration in maintaining physiological balance among protein, fat, and carbohydrate metabolism.

Data Analysis

The analysis of variance (ANOVA) was used to analyze the data and assess the influence of treatment on ration consumption, nutrient digestibility, weight gain, and metabolic status. When significant differences were observed, the next step was Duncan's Multiple Range Test (DMRT) to determine which treatment yielded better results. All data analysis was conducted using SPSS version 25.0 software (IBM Corp, New York, United States).

RESULTS

Feed Intake

The results showed that the combination of protein and energy levels in the ration had no significant effect (P>0.05) on the consumption of dry matter (DM), organic matter (OM) and crude protein (CP) by Pesisir calves (Table 5).

Table 5: Feed intake of dry matter, organic matter, and crude protein (kg/head/day)

Treatment	Dry matter intake	Organic matter intake	Crude protein intake
A	3.11±0.32	2.83±0.29	0.82±0.80
B	3.10±0.35	2.95±0.34	0.93±1.00
C	3.13±0.28	2.91±0.26	0.86±0.67
D	3.27±0.01	3.03±0.01	1.00±0.54

Note: A (CP 12%: TDN 60%), B (CP 14%: TDN 60%), C (CP 12%: TDN 65%), and D (CP 14%: TDN 65%), NFE (nitrogen-free extract), TDN (total digestible nutrient), CP (crude protein). There was no significant difference among treatments in the column (P>0.05).

However, numerically, increasing the energy content (TDN) from 60 to 65% tends to increase consumption at both 12 and 14% protein levels. Treatment D (CP 14% and TDN 65%) had the highest DM intake (3.27kg/head/day) among the treatments.

Daily Weight Gain (DWG), Ration Efficiency (RE) and Feed Conversion Ratio (FCR)

There was no significant difference (P>0.05) in average daily weight gain (DWG) among the treatments, but there was an increasing trend as protein and energy levels increased. Treatment D recorded the highest DWG of 588g/day, followed by treatment C (540g/day), B (490g/day), and A (413g/day) (Table 6). Weight gain is prominent in the 65% TDN diet, suggesting that the energy required to synthesize body tissue was more than sufficient; thus, the nutrients were utilized efficiently.

Table 6: Daily weight gain, ration efficiency, and feed conversion ratio

Treatment	DWG (g/hari)	RE (%)	FCR
A	413±4.78c	13.25±0.03a	7.54±1.48a
B	490±5.14b	15.82±0.04b	6.32±1.85b
C	540±5.39a	17.23±0.06c	5.80±1.93c
D	588±6.59a	17.93±0.08c	5.57±2.30c

Note: A (CP 12%: TDN 60%), B (CP 14%: TDN 60%), C (CP 12%: TDN 65%), and D (CP 14%: TDN 65%), NFE (nitrogen-free extract), TDN (total digestible nutrient), CP (crude protein). Values (mean+SD) bearing different letters in a column differ significantly (P<0.05).

The study has shown that the protein-energy ratio in the ration influenced the feed efficiency and FCR of Pesisir calves. The FCR value of 5.57 and the RE value of 17.93% in the CP 14% and TDN 65% treatment (Treatment D) were good and were attributed to the progressive rise in protein and TDN levels, which significantly and positively affected the results (P<0.05). On the other hand, the treatment with the lowest ratio (CP 12%: TDN 60%) had the least efficient production (RE 13.25%) and the highest FCR (7.54); hence, feed was not utilized efficiently (Table 6).

Nutrient Digestibility

The digestibility of dry matter, organic matter, and crude protein was significantly (P<0.05) different among the treatments, as shown in Table 7. The DMD values increased from 60.22% in treatment A to 64.61% in treatment D, while the OMD values increased from 62.85 to 67.57%. Crude protein digestibility (CPD) followed the same trend, with treatment D having the highest value (79.83%) and treatment A the lowest (73.84%). This rise in digestibility signals better synchronization of energy and protein, helping rumen microbes make more efficient use of nitrogen for microbial protein synthesis.

Table 7: Digestibility of dry matter, organic matter, crude protein

Treatment (%)	Dry matter digestibility	Organic matter digestibility	Crude protein digestibility
A	60.22±1.41c	62.85±1.53d	73.84±1.42c
B	60.16±0.88c	63.75±1.50c	74.41±1.85c
C	61.58±0.45b	65.20±0.46b	75.49±1.89b
D	64.61±0.93a	67.57±1.38a	79.83±2.19a

Note: A (CP 12%: TDN 60%), B (CP 14%: TDN 60%), C (CP 12%: TDN 65%), and D (CP 14%: TDN 65%), NFE (nitrogen-free extract), TDN (total digestible nutrient), CP (crude protein). Values (mean+SD) bearing different letters in a column differ significantly (P<0.05).

Blood Metabolite Profile

The blood glucose, urea, and cholesterol measurements for Pesisir calves are presented in Table 8. The high levels of protein and energy in the diet significantly affected cholesterol and urea (P<0.05), but did not affect glucose (P>0.05). Treatment D had the highest glucose level (80.33mg/dL), the lowest urea level (23.98mg/dL), and the lowest cholesterol level (177.5mg/dL) compared with the other treatments. The low urea and cholesterol levels in diet D can be interpreted as a sign of high nitrogen and fat metabolism efficiency, which means that more of the nitrogen from the feed is used for body tissue synthesis and less is excreted.

Table 8: Blood metabolite profile

Treatment (mg/dL)	Cholesterol	Glucose	Urea
A	257.13±5.53a	72.33±5.25	32.00±7.41b
B	238.85±8.24b	73.40±6.72	34.63±14.43a
C	182.55±3.57c	77.13±9.55	22.48±7.27c
D	177.53±8.28c	80.33±3.11	23.98±4.59c

Note: A (CP 12%: TDN 60%), B (CP 14%: TDN 60%), C (CP 12%: TDN 65%), and D (CP 14%: TDN 65%), NFE (nitrogen-free extract), TDN (total digestible nutrient), CP (crude protein). Values (mean+SD) bearing different letters in a column differ significantly (P<0.05).

DISCUSSION

Feed Intake

The consumption of dry matter (DM), organic matter (OM), and crude protein (CP) in Pesisir cattle calves increased as the protein-to-energy ratio in the ration increased. Although the differences were not statistically significant (P>0.05), the increase in consumption from treatment A (CP 12%: TDN 60%) to D (CP 14%: TDN 65%) reflects improvements in palatability, energy-nitrogen synchronization, and rumen fermentation balance. Treatment D resulted in the highest dry matter intake (3.27kg/head/day), followed by C (3.13kg/head/day), A (3.10kg/head/day), and B (3.11kg/head/day). Increasing TDN from 60 to 65% increase the availability of fermentable energy for rumen microbes, resulting in more efficient fermentation and microbial protein synthesis. As a result, feed retention time in the rumen increased, and total consumption increased to meet the body's energy and protein requirements.

The tendency to raise crude protein intake in high-energy diets also means that the feed utilization efficiency is higher. Treatment D had the highest CP consumption (1.00kg/head/day) among all treatments, suggesting that the feed's nitrogen is being used for tissue protein synthesis rather than being converted into ammonia. Chumpawadee et al. (2005), Oliveira et al. (2020), Freiria et al. (2022), and Oliveira et al. (2025) have pointed out that the main factors affecting nitrogen metabolism efficiency and digestive enzyme activity are the synchronization of energy and protein supply. On the other hand, the extremely low intake in Treatment A indicates an energy deficiency, resulting in reduced digestibility and growth rates due to reduced rumen fermentation efficiency. Consequently, the combination of 14% CP and 65% TDN yields the highest feed intake, the most efficient nutrient utilization, and the highest yield in Pesisir calves.

Daily Weight Gain (DWG), Ration Efficiency (RE), and Feed Conversion Ratio (FCR)

In the Pesisir, calves' increased growth performance was attributed to an escalation in the protein and energy content of the diet. The differences between the treatments were not statistically significant (P>0.05); however, the patterns showed an increase in daily weight gain (DWG) as the protein-energy ratio increased. The highest DWG of 588 g/head/day was observed in Treatment D (CP 14%: TDN 65%), possibly due to a good balance between tissue protein requirements and metabolic energy. The nitrogen and energy synchronization in this ratio resulted in better microbial protein synthesis and lower nitrogen loss as ammonia. Conversely, treatment A (CP 12%: TDN 60%) produced the lowest DWG (413g/day) because energy limitations prevented rumen microbes from maximally utilizing nitrogen from the feed.

The phenomenon of increased performance at high protein–energy levels is consistent with the findings of Pazla et al. (2021), who stated that the protein-to-energy ratio determines the efficiency of microbial protein synthesis and the growth of young Pesisir cattle. The highest increase in TDN would result in the most digestible and palatable feed for the calves (Mahanta & Karnani, 2010; Rosmalia et al., 2022; Cazzuli et al., 2023). Regarding this, Micek et al. (2019), Golubenko & Razanova (2022) and Nofriantika et al. (2022) research prove that synchronization of protein and energy leads not only to energy efficiency (EE) but also to the feed conversion ratio (FCR), which corresponds with the study that mentioned a decline in FCR to 5.57 under Treatment D. Nevertheless, these findings were in some way contradictory to those of Pazla et al. (2024), who claimed that the young female Pesisir cattle had lower growth efficiency at protein levels above 12%. The discrepancy may be due to the physiological and metabolic differences between young calves, which have a greater need for protein to build active muscle tissue. In contrast, adults use excess protein for energy. Hence, the protein/energy balance should be tailored to the animals' growth stage and metabolism.

Ration efficiency (RE) and feed conversion ratio (FCR) are the parameters that reflect the speed of nutrient metabolism of animals in relation to their body weight. The data indicate that Treatment D was the most favorable one in terms of RE (17.93%) and FCR (5.57), whereas Treatment A was the least favorable one in terms of RE (13.25%) and FCR (7.54). This enhancement in metabolic efficiency can be attributed to sufficient energy, which supports microbial protein synthesis and effective nitrogen absorption. Energy from 65% TDN allows for more optimal protein assimilation into body tissue due to the balance between easily fermentable carbohydrates and gradually degradable protein.

The results of the study provide evidence to support the claim by Nofriantika et al. (2022) that augmenting feed energy to 65% in the diets of local cattle can decrease FCR, along with a concomitant increase in energy efficiency, attributed to enhance nitrogen retention. Physiologically, this condition indicates that feeding with balanced energy and protein content optimizes metabolic enzyme activity in the liver and muscles, which are involved in glycogen and structural protein synthesis. Additionally, these results are consistent with the reports by Ahmad et al. (2020), Ma et al. (2021) and El-Waziry et al. (2022), which state that increasing energy levels improves ration efficiency through enhanced rumen fermentation.

The results of the present study are contrary to those of Apelo et al. (2014), who argued that an increase in protein above 17% in cattle feed would result in a higher FCR because the extra nitrogen was not used and was further broken down into urea. Such a discrepancy suggests that the best protein-energy ratio varies with the species and age of the livestock. In the context of Pesisir cattle, a ratio of 14% protein and 65% TDN has proven to be the most efficient without causing excessive metabolic load. Therefore, this combination can be recommended as the ideal ration formulation to improve energy efficiency, accelerate growth, and reduce feed costs in local tropical cattle production systems.

Nutrient Digestibility

The differences in dry matter digestibility (DMD), organic matter digestibility (OMD), and crude protein digestibility (CPD) were significant (P<0.05), which shows that the protein-to-energy ratio affects digestive efficiency significantly. Treatment D yielded the highest values for

DMD (64.61%), OMD (67.57%), and CPD (79.83%), while Treatment A produced the lowest values of 60.22, 62.85, and 73.84%, respectively. The increase in digestibility in Treatment D indicates that high fermentable energy availability (TDN 65%) promotes the growth of rumen microbial populations and accelerates feed degradation. In addition, higher protein content (14%) provides sufficient nitrogen to support rumen enzyme synthesis, thereby increasing feed conversion efficiency.

These results align with the study by Belanche et al. (2022), which states that nitrogen–energy balance increases the ruminal activity of cellulolytic and amylolytic microorganisms, ultimately increasing the rate of fermentation and the organic matter digestibility. Research by Pazla et al. (2025) also supports these findings: increasing protein to 12% with TDN at 65% in pregnant Pesisir cattle significantly enhanced the digestibility of dry matter and crude protein without increasing blood nitrogen excretion. This confirms that increased digestibility efficiency is determined by the amount of protein and the balance of available metabolic energy.

In contrast, Mezzomo et al. (2017) demonstrated that an increase in protein in local cattle feed is not always followed by an increase in digestibility, due to the formation of protein-tannin complexes in local feed ingredients that reduce rumen degradation. However, in this study, the main feed ingredients, such as Indigofera and corn, have low tannin levels, so they do not inhibit protein degradation. Therefore, feed quality and energy ratio are key factors in improving digestibility.

Thus, the results of this study confirm that a combination of 14% protein and 65% energy creates the most efficient rumen fermentation conditions, with a balance between energy and nitrogen substrates that minimizes nutrient loss and maximizes microbial protein synthesis.

Blood Metabolite Profile

Blood metabolite analysis results show a positive physiological response to increased protein and energy ratios. Treatment D (CP 14%: TDN 65%) produced the highest glucose level (80.33mg/dL) and the lowest urea (23.98mg/dL) and cholesterol (177.53mg/dL) levels. High blood sugar indicates adequate energy stores that support protein synthesis and other metabolic activities. On the contrary, low urea indicates that the nitrogen from the consumed protein is used for cell growth rather than being excreted in urine. Lower cholesterol is also a sign that fat metabolism is efficient since more fat is burned for energy.

Chumpawadee et al. (2005), Oliva et al. (2019), and Han et al. (2022) judged that increasing energy and protein in a balanced proportion leads to reduced blood urea level through enhanced nitrogen utilization. In like manner, these findings corroborate the predictions of Sinclair et al. (2000), Qiao et al. (2019) and Vásquez-Reyes et al. (2024), whereby the synchronization of energy–nitrogen supply stabilizes glucose levels and suppresses blood cholesterol by increasing aerobic metabolism in the liver. Hence, the blood metabolite profile in Treatment D reflects the ideal energy and protein homeostasis, thus supporting efficient growth without metabolic stress.

However, the findings of the present investigation contradict those of Kenny et al. (2002). The latter authors reported that the blood urea level of native cattle fed a high-protein diet increased due to the rapid protein decomposition and insufficient fermentable energy sources. This contradiction highlights that an imbalanced protein-to-energy ratio can lead to metabolic inefficiency, regardless of protein levels. One of the factors contributing to the positive outcome of Treatment D in this study was the balance between nitrogen used for microbial protein synthesis and that used for animal tissue.

The combination of 14% crude protein and 65% TDN is physiologically effective in supporting liver and kidney function, characterized by low plasma urea and cholesterol, with blood glucose raised only to reasonable levels to facilitate tissue metabolism. These findings demonstrate that a balanced feeding strategy improves growth performance and enhances livestock's metabolic status and health.

Conclusion

The combination of 14% crude protein and 65% TDN has been shown to provide the best results in Pesisir cattle calves, characterized by increased daily weight gain, improved feed conversion efficiency, and higher digestibility of organic matter, dry matter, and crude protein compared to other treatments. The balance between energy and nitrogen supply at this ratio also creates optimal metabolic balance, reflected in increased blood glucose levels and decreased urea and cholesterol levels. Overall, the CP 14%: TDN 65% ratio improves nutrient utilization efficiency, enhances metabolic activity, and maintains the physiological health of livestock, making it the recommended ideal formulation to support optimal growth and sustainable productivity of local Indonesian calves.

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Conflict of Interest: The authors have declared that no conflict of interest

Data Availability: Data will be available upon request.

Ethics Statement: The research has considered the scientific ethics of using livestock in light of the Republic of Indonesia Law Number 41 Year 2014 on Animal Husbandry and Health. Approval for this research was issued by the Ethics Committee of the Faculty of Pharmacy, Andalas University, indicating that the study will be carried out in accordance with the principles of animal welfare, under reference number 96/UN16.10.D.KEPK-FF/2025.

Author's Contribution: RP, MZ, FA, YT: Conceptualization and methodology, drafted the preliminary version of the manuscript, and collaborated on interpreting the results. JJ, MM, HH, WN: Collected the data, drafted the preliminary version of the manuscript, critically revised it, and collaborated on interpreting the results. TT, EMP, GY: Data interpretation, collaborated in interpreting the result, collaborated in interpreting the result, and finalized the manuscript. ZI, DM, ARL: Conducted lab analysis and critical revision, wrote the original draft, and finalized the manuscript. All authors analyzed and interpreted the data, read the manuscript, and approved the final version.

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