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Milk Evaluation and Nutrient Digestibility of Etawa Crossbreed Dairy Goats Fed *Mirasolia diversifolia*, *Gliricidia sepium*, *Indigofera zoolingeriana*, and Palm Concentrate

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ABSTRACT

This study investigates the impact of unconventional forage mixtures, which include *Mirasolia diversifolia (Md), Gliricidia sepium (Gs), Indigofera zoolingeriana (Iz)*, and palm concentrate (PC), as a substitute for company rations on the feeding, nutrient digestibility, dairy output, and quality of milk in Etawa mixed-breed dairy goats. The study was conducted using a design known as a completely randomized design, involving four distinct ration treatments and replicated four times. The research treatments were as follows: Treatment A served as the company's feed management (60% company forage + 40% company concentrate (CC)), B (60% (Md+Gs) + 15% CC + 25% PC), C (60% (Gs+Iz) + 15% CC + 25% PC), D (60% (Md+Iz) + 15% CC + 25% PC). The parameters measured were ration consumption, nutrient digestibility, milk production and quality. The results showed an insignificant impact (P>0.05) on ration consumption, nutrient digestive efficiency, dairy output, and milk quality. In summary, this study concludes that the use of unconventional forage mixtures consisting of *Mirasolia diversifolia, Gliricidia sepium, Indigofera zoolingeriana*, and palm concentrate is able to replace company rations as seen in the parameters of consumption, nutrient digestibility, dairy output and milk quality of Etawa crossbreed dairy goat's milk.

Key words: Etawa crossbreed dairy goat, palm concentrate, milk, *Mirasolia diversifolia, Gliricidia sepium, Indigofera zoolingeriana*.

INTRODUCTION

The farming of Etawa crossbreed dairy goats encounters major obstacles attributed to the scarcity of available forage and the increasing expenses associated with concentrate. The expanding residential areas are further reducing the supply of animal feed forage, while the cost of concentrate is steadily increasing. Arief et al. (2018a) and Suyitman et al. (2017; 2020; 2021) emphasize the urgent need to explore alternative feeds to enhance livestock productivity and business efficiency. Therefore, there is a critical requirement to identify various options for forage and concentrates that provide excellent nutritional quality and promote high production.

Forage in Indonesia, especially grass, has low nutritional quality, which only contains 7-11% crude protein and 50-60% Total Digestible Nutrient (TDN) (Elihasridas et al. 2023a). This condition causes farmers to add other forage sources that have high nutritional quality to get the appropriate nutritional needs and can produce high livestock productivity. One type of forage that has potential in terms of nutrition is tree legumes such as *Indigofera zollingeriana*. *I. zollingeriana*, a member of the Leguminosae family, holds promising potential as a viable forage option for development and utilization. This plant is resistant to drought, flooding, and infertile soil. Badarina et al. (2023) reported that the chemical composition of *I. zollingeriana* was 27% crude protein, 62.62% digestible organic matter, 17.52% crude fiber content, 1.36% crude fat and high digestibility of dry matter (60.56%). *I. zollingeriana* is able to meet the needs and also as a source of feed with good nutritional value.

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It has been confirmed that *Mirasolia diversifolia* possesses exceptional nutritional value as a forage (Pazla et al. 2021a). It contains approximately 84.01% organic matter and 22.89% crude protein (Pazla et al. 2018a). Furthermore, *M. diversifolia* contains a rich supply of phosphorus minerals that might potentially promote rumen bacterial growth (Fasuyi et al. 2010; Pazla et al. 2021b; Pazla et al. 2023a). Additionally, according to Oluwasola and Dairo (2016), *M. diversifolia* plants have a high concentration of amino acids. By incorporating *M. diversifolia* into the ration for Etawa crossbreed dairy goats along with Napier grass as a source of fiber, it has been found to enhance intake, digestive efficiency, and dairy output (Pazla et al. 2022). *M. diversifolia* mixed with cassava leaves gives good production performance as seen in consumption, nutrient digestibility, dairy output, and quality of milk in Etawa crossbreed dairy goats (Arief et al. 2023a, b).

Gliricidia sepium is a woody plant that is easy to find because it is easy to grow and is usually used as a living fence in rural areas. The leaves of *G. sepium* contain valuable nutrients that can be used as fodder for livestock, with crude protein content ranging from 16.82 to 25.08%, crude fiber from 8.61 to 24.57%, crude fat ranging from 2.19 to 12.29%, ash content between 6.67 and 10.15%, and a total digestible nutrient (TDN) range of 35.42 to 40.21% (Adrizal et al. 2021; Arief and Pazla 2023).

Palm concentrate, which consists of a combination of feed ingredients like minerals, rice bran, corn, and palm kernel cake, offers excellent nutrition to support livestock growth and production. It contains around 60-64% of the nutrients that are fully digestible (energy), and 14-16% are crude protein (Arief et al. 2020). The aim of this experiment is to investigate the effects of substituting company forages with a blend of *M. diversifolia* (Md), *G. sepium* (GS), *I. zoolingeriana* (Iz), and substituting company concentrates with palm concentrate (PC) on the intake, nutrient digestibility, dairy output and quality of milk in Etawa crossbreed dairy goats.

MATERIALS AND METHODS

Animal Ethics

This research has received approval from the ethics committee of the Universitas Andalas, Faculty of Medicine, which ensures that the study is conducted in compliance with animal welfare principles. The approval reference number for this research is 33/UN.16.2/KEP-FK/2023.

Experimental Site

The research took place in Payakumbuh, West Sumatera, Indonesia, specifically at Toni Farm company (latitude: -0.2330638, longitude: 100.6268024, and an elevation of 516 m above sea level). In this region, there are two well-defined seasons: the monsoon season lasting from September to February, and the dry season, from March to August. The study was carried out between April and June 2023. Within this time span, the area experienced temperatures ranging from 23 to 36°C.

Animal Experiment and Feeding Formulation

For this study, a total of 16 Etawa crossbreed dairy goats (ECDG) were selected, with a typical weight of 60±1.31kg, and all at their second stage of lactation. The goats were assigned to four different groups based on a completely randomized design, with each group receiving a distinct ration formulation, and a total of four duplicates of each treatment were done. The treatments involved the following: Treatment A served as the company's feed management (60% company forage + 40% company concentrate (CC)), B (60% (Md+Gs) + 15% CC + 25% PC), C (60% (Gs+Iz) + 15% CC + 25% PC), D (60% (Md+Iz) + 15% CC + 25% PC). To produce palm concentrate, the formulation consisted of rice bran makes up 37%, palm kernel cake accounts for 40%, corn constitutes 22%, and minerals comprise 1%. These feed ingredients were carefully blended to ensure homogeneity and the resulting mixture was stored in plastic containers with moisture content maintained at less than 12%.

Bush and native grass were used as the company forage in this study. Feed components such as jackfruit skin, tofu dregs, and cassava without skin were combined to make the company's concentrate. All the ingredients were thoroughly mixed to ensure an even distribution and were provided in a fresh state. The feeding schedule for the animals involved three daily meals, which included *M. diversifolia*, *G. sepium*, *I. zoolingeriana*, and company forages, served at 8:00am in the morning, 1:00pm at midday, and 6:00pm in the afternoon. The concentrate was administered twice daily at 7:00am and 12:00noon.

According to the guidelines provided by the National Research Council (2007), the experimental ration was designed to provide the nutritional requirements of 60kg dairy goats, and capable of producing around 2 to 3kg of milk daily with a fat content of 4%. The chemical properties of each feed component utilized in the ration are detailed in Table 1. Furthermore, Table 2 presents the chemical composition of the treatment ration's feed ingredients along with the corresponding nutrient content of the treatment ration. Proximate analysis of the research feed ingredients was performed, taking into account water content, dry matter, ash, crude protein, crude fat, and crude fiber, following AOAC International (2016) guidelines.

The research spanned 45 days and was divided into three distinct phases: a primary adjustment period lasting 25 days, succeeded by a preparatory phase of 15 days, culminating in a 5-day gathering period. Consumption measurement was calculated based on the formula described by Arief et al. (2023a).

At 6am, feces were gathered, and their fresh weight was recorded. A 10% subsample was collected for each treatment, which was then sun-dried. After drying, the feces underwent grinding into a fine powder to facilitate analysis of their chemical composition. The feed digestibility was determined by evaluating the disparity between fecal production and ration consumption.

The goats underwent milking twice daily, once during morning hours and once during evening hours, utilizing a mechanical milking equipment. The researchers measured dairy output in liters over a period of five days during the collection phase. For each treatment, 250ml milk samples were collected within this time frame. To evaluate the milk quality, various components were subjected to analysis using the Lactoscan Pro 202, including pH, specific gravity, water content, dry matter, protein, lactose, fat, and solid non-fat.

Statistical Analysis

The research utilized a completely randomized design (Model) following the methodology outlined by Steel and Torrie (2002). The analysis involved examining intake, nutrient digestive efficiency, dairy output, and quality of milk. The variance was determined through SPSS software (IBM SPSS Statistics, USA; version 21.0). To assess the differences between treatments, Duncan's Advanced Multiple Range tests were employed.

RESULTS

Treatment of Etawa Crossbreed Dairy Goats' Milk Production

The ration treatment did not have a significant impact (P>0.05) on the milk production of Etawa-crossbreed dairy goats. Rations B, C, and D demonstrated the capability to achieve milk production levels similar to those obtained from company rations (Treatment A). Milk production in Treatment A produced 1.27Liters, while Treatment B produced 1.11Liters, Treatment C produced 1.14Liters, and Treatment D produced 1.32Liters (Fig. 1). Despite not showing a significant disparity (P>0.05) in milk production, Treatment D, which involved a mixture of *Mirasolia diversifolia* and *Indigofera zoolingeriana* with palm concentrate, resulted in the highest milk yield, reaching 1.32Liters. Then followed by the company ration (Treatment A) of 1.27Liters. Meanwhile, rations C and B only had a difference in milk production of 0.03Liters.

Treatment of Etawa Crossbreed Dairy Goats' Milk Quality

Table 3 presents the quality of milk from a combination of various types of unconventional forages and concentrates derived from palm. The analysis showed that there was no significant effect from the ration treatment (P>0.05) on any of the tested milk qualities. Treatment D showed the highest trend of pH (6.40), lactose (4.98%), protein (3.28%), specific gravity (1.030), mineral P (0.99%), and water content (87.15%). The highest content of milk fat and milk dry matter was in treatment C, namely 7.38 and 15.81%. In Treatment C, the Ca mineral content was the highest at 2.45%. Nevertheless, the treatment resulted in the lowest specific gravity of milk, measuring 1.026.

The Feed Consumption of Etawa Crossbreed Dairy Goats Treatment

Consumption of crude protein, dry matter, and organic matter from Etawa cross-breed dairy goats fed mixed rations of various types of unconventional forages and palm concentrates is presented in Table 4. The consumption of crude protein, dry matter, and organic matter among Etawa crossbreed dairy goats showed a non-significant difference (P>0.05) with the ration treatment. Rations B, C, and D have the capability to substitute company rations (Treatment A). While not statistically significant, it was observed that the intake of crude protein, dry matter, and organic matter in Treatment D, which involved a combination of *M. diversifolia* and *I. zoolingeriana* forages with palm concentrate, exhibited the highest values of 2.01, 1.03, and 0.89kg/d, respectively.

Table 1: Chemical content of feed ingredients

Chemical Content (%)	Feed stuff					
	CF	Md	Iz	Gs	PC	CC
Dry Matter	26.03	23.13	21.24	21.42	93.06	30.67
Organic Matter	87.93	84.65	92.41	94.85	94.07	94.33
Crude Protein	25.43	25.07	25.29	19.11	12.53	08.32
Crude Fiber	28.02	22.62	12.87	19.75	19.05	20.37
Crude fat	2.73	1.62	3.64	2.98	3.50	5.82
TDN	56.46	56.72	61.42	66.07	77.54	78.26
NFE	31.75	35.34	40.51	53.01	58.99	59.82
Ash	12.07	15.35	07.59	05.15	5.93	5.67

Total digestible nutrient (TDN), Nitrogen free extract (NFE), *Mirasolia diversifolia* (Md). *Indigofera zoolingeriana* (Iz), *Gliricidia sepium* (Gs), Palm concentrate (PC), Company forages (CF), Company concentrates (CC).

Table 2: Ration composition and chemical content of treatment rations

Feedstuff	Treatments			
	A	B	C	D
Company Forages	60	0	0	0
Mirasolia diversifolia	-	40	-	30
Gliricidia sepium	-	20	15	-
Indigofera zoolingeriana	-	-	45	30
Palm concentrate	-	25	25	25
Company Concentrate	40	15	15	15
Total	100	100	100	100
Chemical Composition				
Dry Matter	27.89	31.40	30.64	31.18
Organic Matter	90.49	90.50	93.48	90.79
Crude Protein	18.59	18.23	18.63	19.49
Crude Fiber	24.96	20.82	16.57	18.47
Crude Fat	3.97	2.99	3.83	3.33
TDN	65.18	67.03	68.67	66.57
NFE	42.98	48.46	49.90	46.48
Ash	9.51	9.50	6.52	9.22

Table 3: Treatment of Milk Quality in Etawa Crossbreed Dairy Goats

Parameter	Goat milk			
	A	B	C	D
pH	6.09±0.08	6.13±0.03	6.10±0,06	6.40±0.39
Fat Level (%)	5.91±1.85	6.59±1.44	7.38±1.55	4.61±1.99
Lactose (%)	4.84±0.14	4.96±0.26	4.70±0,25	4.99±0.25
Solid non-fat (%)	8.74±0.20	9.07±0.47	8.62±0.44	9.05±0.44
Protein (%)	3.16±0.08	3.27±0.18	3.10±0.18	3.28±0.19
Specific Gravity	1.028±0.002	1.028±0.003	1.026±0.003	1.030±0.003
Phosphorus (%)	0.89±0.44	0.93±0.08	0.98±0.20	0.99±0.19
Calcium (%)	2.11±0.55	2.38±0.32	2.45±0.26	2.12±0.28
Water Content (%)	86.09±1.81	85.19±1.26	84.82±1.17	87.15±1.57
Dry Matter (%)	13.91±1.81	14.81±1.26	15.18±1.17	12.85±1.57

There is non-significant difference among treatments (P>0.05).

Table 4: Treatment of Ration Intake in Etawa Crossbreed Dairy Goats

Intake (kg/e/day)	Treatment			
	A	B	C	D
Dry Matter	1.82±0.02	1.97±0.08	1.98±0.07	2.01±0.05
Organic Matter	1.65±0.02	1.77±0.07	1.83±0.04	1.85±0.05
Crude Protein	0.34±0.004	0.36±0.01	0.37±0.009	0.39±0.01

There is non-significant difference among treatments (P>0.05).

Treatment of Etawa Crossbreed Dairy Goats Digestibility

Table 5 presents the digestive efficiency of crude protein, dry matter, and organic matter in Etawa crossbreed dairy goats when they were fed mixed rations consisting of different types of unconventional forages and palm concentrates.

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Table 5: Treatment of Digestibility in Etawa Crossbreed Dairy Goats

Digestibility	Treatment			
(%)	A	B	C	D
Dry Matter	72.65±1.23	71.77±3.21	70.81±2.20	70.49±1.42
Organic Matter	73.79±1.27	72.10±3.15	71.63±2.07	70.62±1.15
Crude Protein	76.89±1.81	75.99±2.59	74.25±2.62	75.63±1.20

There is non-significant difference among treatments (P>0.05).

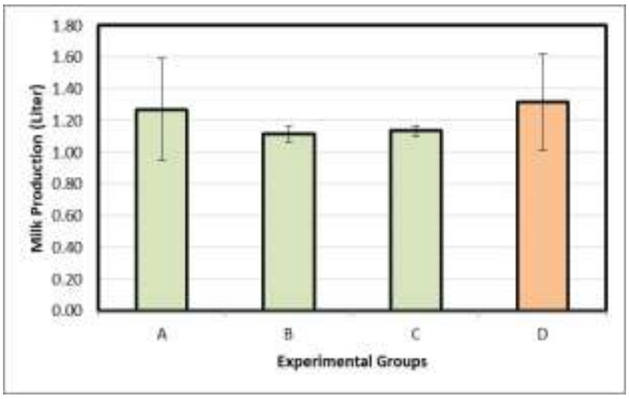

Fig. 1: Treatment of Milk Production in Etawa Crossbreed Dairy Goats: There is non-significant difference among treatments (P>0.05).

The evaluation of ration treatments revealed no statistically significant variance (P>0.05) in the digestive efficiency rates of crude protein, dry matter, and organic matter among the population of Etawa crossbreed dairy goats. Rations B, C, and D are able to replace company rations (Treatment A). Although not statistically significantly different, the digestive efficiency of crude protein, dry matter, and organic matter in the treatment of a mixture of *M. diversifolia* and *I. zoolingeriana* forages with palm concentrate (Treatment D) showed the highest values respectively 66.78, 68.21 and 70.86%, respectively.

DISCUSSION

Treatment of Etawa Crossbreed Dairy Goats Milk Production

The quality of the feed provided to the livestock significantly affects the amount of milk produced. The fact that milk production did not show a statistically significant variation among A, B, C, and D treatments indicates that the four types of rations administered had almost identical quality. The quality of the ration can be assessed based on its composition and nutritional content. The nutritional content of the ration which plays a very important role in milk production is protein and energy in the form of TDN. The treatment ration protein was not much different, namely A (18.59%), B (18.23%), C (18.63%), D (19.49%) (Table 2). The TDN of the rations given was also not much different, namely A (65.18%), B (67.03%), C (68.67%), D (66.57%) (Table 2). The protein and energy balance (Total Digestible Nutrients - TDN) among these treatments plays a significant role in milk production, and there is no significant difference in the resulting milk production.

Feed consumption also greatly affects the amount of milk production produced. Table 3 shows that the feed consumption among the treatments did not exhibit any significant difference (P>0.05), resulting in similar milk production, which was also consistent between the treatments. Consumption of feed protein is closely related to milk production. Arief et al. (2023b) said that the protein content of the feed is an element of milk lactose formation. The higher the consumption of ration protein, the lactose level will also increase. Lactose is water binding. High levels of lactose will lead to high milk production. Fig. 1 shows treatment D, namely rations containing *M. diversifolia, I. zoolingeriana* and palm concentrate, showing higher milk production than treatments A, B and C. High milk production in treatment D is also in line with lactose levels and high protein consumption in treatment D, namely 4.99% and 0.39kg each day. The results of this research demonstrate higher values than those reported by Dzarnisa et al. (2018) in their research, where they fed Etawa crossbreed goats with mangosteen peel flour, resulting in a daily production of 0.41Liters. The difference in results is due to variations in the types of rations provided.

Etawa Crossbreed Dairy Goat's Milk Treatment Quality

Nutritional elements contained in the feed have a significant impact on milk quality, and milk with good quality must meet the established standards of milk quality. The statistical analysis results indicate that there were non-significant differences (P>0.05) across all milk quality parameters. The replacement of the company's forages with a mixture of *M. diversifolia, G. sepium, I. zoolingeriana*, and the substitution of the company's concentrate with palm concentrate had no impact on milk quality. Milk quality achieved in treatments A, B, C, and D remained within the standard range as defined by the Thai Agricultural Standard (2008). The reaction of ECDG to diets comprising palm concentrate and a mixture of *M. diversifolia, G. sepium,* and *I. zoolingeriana* forages is quite satisfactory, as demonstrated by this result.

There was a non-significant difference in milk quality among treatments (P>0.05), likely due to the similarity in feed quality factors such as TDN and crude protein among the treatments. This finding was supported by Arief et al. (2018a), who stated that the type of feed has an influence on the milk produced. Additionally, feed with good quality enhances metabolism in animals by providing sufficient energy and vitamins for milk component synthesis (Arief et al. 2018b). Furthermore, the treatments had similar intakes of crude protein, dry matter, and organic matter which contributed to the absence of differences in milk quality. In the rumen, the final fermented product is not significantly affected by the intake and digestibility of the same feed, particularly the production of volatile fatty acids (VFA). Rumen bacteria receive enough energy for growth and development from VFA production (Jamarun et al. 2019), and it also supplies raw materials for the synthesis of milk (Jamarun et al. 2020). The results of this investigation support the findings of Pazla et al. (2022), who observed no significant disparities in milk quality for Etawa crossbreed dairy goat that received a mix of tithonia forage and elephant grass, combined with a concentrate made of palm kernel cake, corn, rice bran, dregs from tofu, and rice bran. Marques et al. (2022) also obtained similar results, showing no variation in the quality of milk from goats when given a forage blend containing both cassava and alfalfa.

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Treatment of Feed Intake in Etawa Crossbreed Dairy Goats

Since dry matter contains necessary food components, it can be consumed to provide energy for the production of milk, which includes organic components like carbohydrates, fat, and protein (Jamarun et al. 2021). The study's findings on the intake of crude protein, dry matter, and organic matter, achieved by substituting the concentrate provided by the company with palm concentrate and substituting the company's forages with *M. diversifolia, G. sepium, I. zoolingeriana*, are shown in Table 5. Substituting the company's concentrate with palm concentrate and substituting the company's forages with *M. diversifolia, G. sepium, I. zoolingeriana* in the ration resulted in no notable distinction (P>0.05) among treatments concerning the intake levels of crude protein, dry matter, and organic matter. The composition of the ration may have contributed to the lack of a discernible difference between each treatment. When replacing the concentrate provided by the company with palm concentrate and the company's forages with *M. diversifolia, G. sepium, I. zoolingeriana*, it is crucial to carefully consider the content of dry matter in each feed ingredient. The concentrate provided by the company has a dry matter content of 30.67%, while palm concentrate has a significantly higher dry matter content of 93.06% (Table 1). On the other hand, the dry matter content of the forages provided by the company with *M. diversifolia, G. sepium, I. zoolingeriana* showed minimal variation. Despite this, when substituting ingredients, the ration exhibited different dry matter content levels: ration A at 27.89%, ration B at 31.40%, ration C at 30.84%, and ration D at 31.18% (Table 2). However, even with the rise in the ration's dry matter content, no notable variation in intake was observed. This observation finds support in the research of Pazla et al. (2018b), who argued that nutrient intake is contingent on both the dry matter quantity in the consumed feed and the nutritional composition of the provided feed. The study also uncovered that livestock could consume significant quantities of feed, which is influenced by their individual requirements, in accordance with the findings of Arief et al. (2021a, 2021b). Arief et al. (2018a) reported that the number of feeds needed by livestock, particularly goats, is influenced by their feeding capacity and total body weight. The results from this study showed higher values compared to those reported by Setyaningsih et al. (2013), who recorded an average intake of dry matter of 1.55-1.66 kg per day with a 43 kg average body weight. This disparity is likely attributed to the livestock's rumen capacity, which impacts their dry matter intake.

The palatability of feed is a significant factor influencing dry matter intake and livestock preferences. In a recent study by Pazla et al. (2021c), it was discovered that dairy goats showed a preference for *M. diversifolia, I. zoolingeriana*, and palm concentrate due to their favorable palatability. The feed's palatability directly affects the livestock's interest and appetite, and factors like flavor, texture, smell, and taste play a crucial role in this regard. The observations from the study strongly indicate that *M.diversifolia, I. zoolingeriana,* and palm concentrate possess appealing flavors, making them attractive options for the goats' diet. The organic matter consumption is directly related to dry matter intake, where organic components form a portion of it but are diminished by inorganic elements. The fluctuation in the consumption of organic matter is notably impacted by the constituents present in dry matter, as highlighted in the research by Kamalidin et al. (2012). The close relationship between organic matter and dry matter is further corroborated by Febrina et al. (2017), who emphasize that organic matter is an integral part of dry matter. Consequently, if livestock have a low dry matter intake, their intake of organic matter will similarly be reduced. Furthermore, specific components of organic matter, such as crude protein, ether extract, and crude fiber, have a strong influence on the consumption of organic matter.

A significant increase in the consumption of dry matter leads to a corresponding rise in organic matter intake. However, it is important to note that the elevation in organic matter intake is not solely reliant on feed; livestock also plays a crucial role as one of the contributing factors in enhancing the consumption of organic matter. The consumption of organic matter can also be influenced by the feed-eating ability and preference of livestock. Murni et al. (2012) highlighted additional factors contributing to intake, comprising elements such as livestock body mass, feed digestive efficiency, palatability, feed quality, and the animals' ages.

The intake of crude protein, which showed no significant distinctions among treatments (P>0.05), can be attributed to the similar protein content in the rations across the treatments: A (18.59%), B (18.23%), C (18.63%), and D (19.49%) (Table 2). According to Jamarun et al. (2023), the intake of feed with crude protein demonstrates a direct correlation with the consumption of both dry and organic matter. Their study also found a positive correlation between feed protein and the intake of energy, protein, and dry matter. The intake of feed has an impact on the consumption of other nutrients. As highlighted by Pazla et al. (2023b), the factors that influence feed protein intake include both the intake of the protein and dry matter present in the feed. In this study, the intake of crude protein surpassed that of Marwah et al. (2010), who provided Etawa crossbreed dairy goat with 0.34kg/d of crude protein through a diet of *Calliandra calothyrsus* and concentrate, as well as Krisnan et al. (2015), who reported a daily intake of 0.24kg per head by feeding concentrates and mixture *Leucaena leucocephala* with *Pennisetum purpupoides*.

Treatment of Digestibility in Etawa Crossbreed Dairy Goats

The protein and energy content (TDN) in all treatment rations were comparable, leading to no significant differences in the digestibility of dry matter, organic matter, and crude protein rations. TDN is energy in feed ingredients that is positively correlated with digestibility. According to Pazla et al. (2021c), the resulting digestibility is mainly influenced by the balance of protein and energy in the ration. Jamarun et al. (2017a) and Hao et al. (2018) found that a well-balanced supply of nutrients offers advantages for bacteria, leading to increased microbial growth and improved nutrient digestibility.

In the rumen, rumen microbes play a vital role in feed digestion, with rumen growth (which involves microbial protein synthesis) being predominantly influenced by the

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availability of protein and energy sources (Jamarun et al. 2017b; Putri et al. 2019; 2021). According to Zain et al. (2023), the digestibility of feed ingredients is influenced by their chemical composition, especially the energy and protein of these feed ingredients. An adequate and balanced supply of energy and protein plays a crucial role in creating an optimal fermentation environment in the rumen, leading to increased growth and performance of rumen microbes, which in turn results in improved feed digestibility (Krehbiel 2014).

The incorporation of a mixture of forages and palm concentrates in rations as a substitute for company rations did not significantly affect the digestibility of dry matter, organic matter, and ration protein. Nevertheless, Treatment D, a combination of *M. diversifolia* with *I. zoolingeriana* and palm concentrate, exhibited the highest digestibility value. This decrease is thought to be due to a decrease in the crude fiber content of the rations. Pazla et al. (2020; 2021d; 2023c) states that the low crude fiber content in the feed will make it easier for rumen microbial enzymes to penetrate into the feed material for the digestion of food substances. The digestibility of feed is impacted by its chemical composition, and the proportion of fibrous feed significantly affects nutrient digestibility (Jamarun et al. 2017c; Yanti et al. 2021; Elihasridas et al. 2023b).

Conclusion

The substitution of the forages of the company with a blend of *M. diversifolia*, *G. sepium*, and *I. zoolingeriana*, as well as the replacement of company concentrate with palm concentrate, had no impact on the intake, digestive efficiency, dairy output and milk quality produced by Etawa crossbreed dairy goats. The incorporation of 60% *M. diversifolia* and *I. zoolingeriana*, along with 15% company concentrate and 25% palm concentrate, successfully sustained the intake, digestive efficiency, dairy output, and milk quality produced by Etawa crossbreed dairy goats.

Author Contributions

AA and NJ searched for funding, designed the study concept and supervised the field. RP conducted data analysis, laboratory work, and drafting. RW supervised laboratory works.

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