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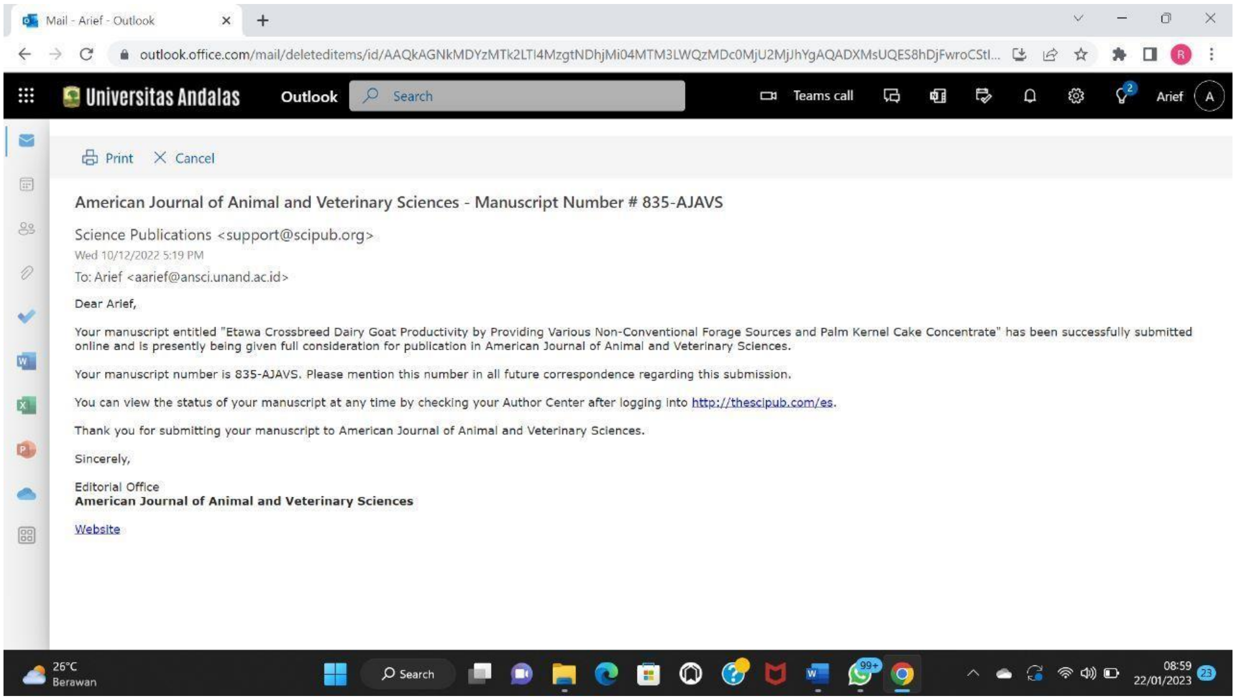

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Original Research Paper

# Etawa Crossbreed Dairy Goat Productivity by Providing Various Non-Conventional Forage Sources and Palm Kernel Cake Concentrate

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**Abstract -** This research aimed to study the production and milk quality of Etawa Crossbreed Dairy Goat (ECDG) fed with several sources of forage with palm kernel cake concentrate (PKCC). The design of the experiment wasa randomized completely design with four treatments of feed formulation. Treatment formulations are as follows: A). 50% tofu waste (TW) + 50% field grass (company ration as a control); B). 25% TW + 25% PKCC + 50% tithonia (*Tithonia diversifolia*); C). 25% TW+ 25% PKCC + 50% cassava leaves (*Manihot utilisima*); D). 25% TW + 25% PKCC + 50% Gamal (*Gliricidia sepium*). The ratio of concentrate and forage is 50:50. PKCC consists of 30% palm kernel cake, 40% tofu waste, 20% rice bran, 9 % corn, and 1% mineral. The parameters measured were dry matter intake (DMI), organic matter intake (OMI), crude protein intake (CPI), dry matterdigestibility (DMD), organic matter digestibility (OMD), crude protein digestibility (CPD), milk production, and milk quality (protein, lactose, fat, Solid Non-fat (SNF), Total Solid (TS), pH, specific gravity, and mineral of milk (Ca and P). Data were analyzed by Analysis of Varian and Duncans Multiple Range Test. The results showed the treatment had no significant effect (P>0.05) on milk production, SNF, pH, specific gravity, and P. However, the effects were significant (P<0.05) on parameters such as DMI, OMI, CPI, DMD, OMD, CPD, protein, lactose, fat, TS, and Ca of milk. From this study, it can be concluded that replacement of field grass with various forage sources (tithonia, cassava leaves, and gamal) and replacement of tofu waste with concentrate-based palm kernel cake can increase feed intake,digestibility, protein, lactose, fat, and calcium of milk but did not significant affected on milk production, SNF, total solids, pH, and specific gravity of milk.

**Keywords:** cassava leaves, Etawa crossbreed dairy goat, *Gliricidia sepium*, palm kernel cake, *Tithonia diversifolia.*

## Introduction

Forage such as elephant grass is the main feed for ruminants to provide crude fiber. In addition to forages, other unconventional forage sources are tithonia (*Tithonia diversifolia*), cassava leaves (*Manihot utilisima*), and gamal (*Gliricidia sepium*). Tithonia is a shrub or weed-like plant that grows a lot in an empty land, roadsides, and rice fields. In West Sumatra, tithoniais also known as the paitan plant because of its bitter leaves (Pazla *et al.*, 2021a). Tithonia plants have notbeen widely used as a source of organic material, a source of fertilizer, or animal feed ingredients. However, tithonia is quite favored by livestock because its high

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protein content of 22.98% (Jamarun *et al.,* 2019). Also, cassava leaves and gamal are nutritious foraged ingredients that are useful as a forage source for livestock.

Furthermore, livestock needs concentrated feed ingredients for energy. The price of concentrate feed ingredients, especially corn, is expensive due to imported feed. Therefore, it is necessary to look for alternative feed ingredients with abundant availability and quality to reduce dependence on imported feed ingredients. One of the concentrate feed ingredients that meet the requirements above is a by-product of the palm oil processing industry, namely palm kernel cake (PKC). Viewed from the production aspect, 60% of the totalpalm oil industry products are by-products. It is including PKC which is useful as an alternative feed ingredient for livestock because it has good nutritional composition and great potential as a source of concentrated feed ingredients for livestock (Arief *et al.,* 2019a).

In addition to dairy goats, livestock that can be developed as milk-producing is Etawa Crossbred Dairy Goats (ECDG). The ECDG crosses between an Etawa goat and a local Indonesian goat, namely Kacang Goat. The advantage of ECDG is that they have good adaptability to most parts of Indonesia. ECDG are dual-purpose type goats that have good reproductive characteristics, better nutritional milk content than cow's milk (Arief *et al.,* 2019b). ECDG is raised for milk production especially in Indonesia (Arief *et al.,* 2019b). Goat's milk contains minerals Ca, P, and Mg which are higher than cow's and human's milk. The high content of medium-chain fatty acids is beneficial for the body because it is rapidly oxidized by the liver and induces a full effect (Vaquil and Rathee, 2017). Besides, goat's milk has medicinal properties that can cure various diseases such as asthma and tuberculosis (Pal U *et al.,* 2011).

Research on the use of various forage sources combined with the provision of by-products from thepalm oil industry and tofu waste as feed ingredients for lactating ECDG concentrates has never been carried out. If this potential is explored properly, non-conventional forage sources and the palm oil industry will play asignificant role in providing animal feed, especially dairy goats, which are useful for supporting food self- sufficiency programs, especially milk in Indonesia (Pazla, 2018a).

## Materials and Methods

### *Ethical Approval*

This experiment has referred to research ethics using livestock based on the Republic of Indonesia government law number 18 of 2009 (Section 66), which addressed animal keeping, raising, killing, and proper treatment and care.

### *Experimental Design*

This research was conducted at an ECDG livestock company in Payakumbuh, West Sumatra, Indonesia (-0.2330638,100.6268024). There were 16 ECDGs in the second month of lactation used in this research. The selected ECDG is 1-1.5 years old with a weight of 58-60 kg. This experiment used 4x4 randomized completely design determined by four treatments of feed formulation (A). 50% tofu waste (TW) + 50% Field grass (company ration as a control); B). 25% TW + 25% Kernel Cake Concentrate (PKCC) + 50% tithonia; C). 25% TW+ 25% PKCC + 50% cassava leaves; D).25% TW + 25% PKCC + 50% Gamal) for a total of 16 experimental units. ECDG are placed in individual cages with a size of 1.25 m x1.00 m. The experimental cage was given disinfectant and all ECDG were given deworming beforethe study started. All ECDGs were confirmed not to havemastitis.

**Table 1**. The nutritional content of each feed ingredient.

| Nutrient (%) | Feedstuff | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Fields grass | T | CL | G | Rice bran | Tofu waste | PKC | Corn |
| Dry Matter | 23.29 | 25.57 | 31.10 | 21.42 | 87.80 | 28.40 | 91.83 | 85.80 |
| Organic Matter | 92.41 | 84.01 | 89.85 | 94.85 | 90.80 | 97.67 | 91.41 | 99.10 |
| Protein | 10.23 | 22.98 | 27.15 | 19.11 | 10.72 | 20.11 | 12,36 | 07.70 |
| Crude Fiber | 25.44 | 18.17 | 19.12 | 19.75 | 11.60 | 19.00 | 26.68 | 02.44 |
| Extract Ether | 3.64 | 04.71 | 3.52 | 2.98 | 08.73 | 01.25 | 8,23 | 03.50 |
| NFE | 53.1 | 38.15 | 39.26 | 53.01 | 59.75 | 57.31 | 44.14 | 85.46 |
| NDF | 67.20 | 55.03 | 56.13 | 46.33 | 55.13 | 59.28 | 66.70 | 49.96 |
| TDN | 58.65 | 62.60 | 79.21 | 67.60 | 66.63 | 74.61 | 65.40 | 81.90 |

Note: T= Tithonia, CL = Cassava leaf, G=Gamal, PKC = Palm Kernel Cake, NFE = Nitrogen Free Extract, NDF =Neutral Detergent Fiber, TDN = Total Digestible Nutrient

**Table 2**. The composition and nutrients of palm kernel cake concentrate (%DM)

| Feed Ingredients | Level (%) |
|---|---|
| Palm kernel cake | 40.00 |
| Rice bran | 20.00 |
| Corn | 9.00 |
| Tofu waste | 30.00 |
| Mineral | 1.00 |
| **Nutrient** | **Percentage (%)** |
| Dry matter | 91.84 |
| Ash | 9.88 |
| Crude protein | 16.88 |
| Crude fiber | 13.22 |
| NFE | 55.06 |
| NDF | 62.84 |
| TDN | 66.36 |

Note: NFE = Nitrogen Free Extract, NDF =Neutral Detergent Fiber, TDN = Total Digestible Nutrient

**Tabel 3**. Composition of treatments ration (%)

| Feed Materials | Treatments | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Field grass | 50 | 0 | 0 | 0 |
| Tithonia | - | 50 | 0 | 0 |
| Cassava | - | - | 50 | 0 |
| Gamal | - | - | 0 | 50 |
| PKCC | - | 25 | 25 | 25 |
| Tofu waste | 50 | 25 | 25 | 25 |
| Total | 100 | 100 | 100 | 100 |
| Nutrient composition | | | | |
| Dry Matter | 25.85 | 42.85 | 45.61 | 40.77 |
| Ash | 4.96 | 11.05 | 8.13 | 5.63 |
| Protein | 15.17 | 20.74 | 22.82 | 18.80 |
| Crude Fiber | 14.48 | 17.14 | 18.02 | 17.93 |
| NFE | 55.21 | 47.17 | 47.72 | 54.60 |
| NDF | 63.24 | 58.05 | 58.60 | 53.70 |
| TDN | 66.63 | 66.54 | 74.85 | 69.04 |

Note: NFE = Nitrogen Free Extract, NDF =Neutral Detergent Fiber, TDN = Total Digestible Nutrient

The experimental ration consisted of forage and concentrate in a ratio of 50:50. The ration was given at 3.5 % of body weight-based dry matter (NRC, 2007). Drinking water is available ad libitum. The nutritional content of each feed ingredient is presented (Table 1). The composition and nutritional content of palm kernel cake-based concentrates are presented (Table 2). The composition and nutritional content of the experimental rations are explained (Table 3). Proximate analysis of feed ingredients (dry matter, ash, protein, extract ether, and crude fiber) was carried out following (AOAC, 2005). NDF was determined following (Goering and Van Soest, 1970). TDN was estimated with this following formula (Moran, 2005):

$$TDN = 5.31 + 0.412\ CP\% + 0.249\ CF\% + 1.444\ EE\% + 0.937\ NFE\%$$

Where: CP = crude protein; CF = crude fiber; EE = extract ether; NFE = nitrogen free extract

The experiment was carried out for 50 days consisting of 30 days of the adaptation period, 15 days of the preliminary period, and 5 days of collecting period.

### *Collection of Feces Samples*

The sewage collection from the ECDG was carried out for 5 days, namely the 46th day to the 50th day. The dirt is weighed every day at 8 am which is called the weight of fresh dirt. Then, 10% of the dirt is taken to dry in the sun and then weighed which is called the weightof dry dirt. Before analysis in the laboratory, goat hair attached to the manure is removed.

### *Milk Sample Collection*

Every day the milk production of each experimental animal was weighed and recorded. Milk samples were taken 2 times during the study for quality testing. Before sampling, the nipples were cleaned. Then, 300 mL of milk from each experimental animal was taken and stored in a cool box to avoid microbes' contamination. Finally, milk samples are taken to the laboratory foranalysis of milk quality.

### *Parameters Measured*

The variables measured were dry matter intake (DMI), organic matter intake (OMI), crude protein intake(CPI), dry matter digestibility (DMD), organic matter digestibility (OMI), Crude protein digestibility (CPI), milk production, and milk quality (milk protein, lactose, milk fat, total solid (TS), Solid Non-Fat (SNF), pH, BJ, Ca and P mineral). Protein, lactose, and fat were measured using the method of (AOAC, 2005), SNF and TS were measured using lactoscan MCC50, pH was measured using pH meter digital, while Specific Grafity was measured using a Lactodensimeter.

### *Statistical Analysis*

Experimental data were analyzed using the analysis of variance (ANOVA) in SPSS version 20. Parameters means show statistical differences in probabilities level of P<0.05 compared using the Duncan multiple range tests.

## Results

### *Milk Production*

Optimal milk production and quality is the goal and hope for dairy goat farmers. The quality of feed greatly determines the optimal production and quality of milk. Milk production in this study did not differ (P>0.05) between treatments, but treatments that received various types of forage (tithonia, cassava leaves, and gamal) and PKCC showed higher milk production compared company ration (treatment A) (Fig. 1).

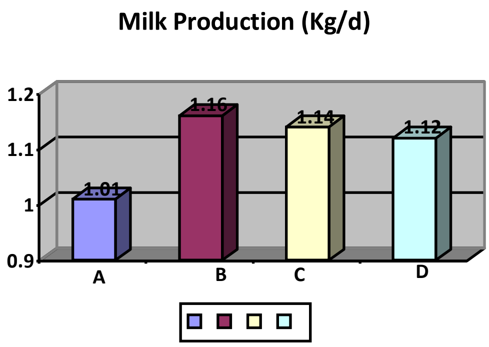


Fig.1: Milk production as affected by treatments

### *Milk Quality*

The results on the quality of ECDG goat milk showed that treatment C has the highest milk protein content (Table 4) which was not significantly different (P<0.05) with treatment B and D. Treatment B resulted in higher levels of lactose (P<0.05) compared to other treatments. The highest milk fat content was found in treatment B which was not significantly different (P<0.05) with treatment D. The highest SNF was obtained due to the high protein and lactose content in treatment B. The statistical analysis results showed that there was no significant difference (P<0.05) between treatments on the specific gravity of milk. Treatment B has the highest total solid, 21.78%, and treatment A exhibits the lowest total solid, which is 16.87%. The pH value of milk in this study was 6.76-6.86. The content of Ca and P in treatment A exposes the lowest value when compared to treatments B, C, and D, which receivedingredients from tithonia forage, cassava leaves, and gamal as well as PKCC.

**Table 4**. Milk quality as affected by treatments.

| Parameters | Treatments | | | | SEM |
|---|---|---|---|---|---|
| | A | B | C | D | |
| Protein (%) | 4.89$^a$ | 5.99$^b$ | 6.26$^b$ | 6.01$^b$ | 0.25 |
| Lactose (%) | 5.58$^a$ | 6.73$^a$ | 3.55$^b$ | 3.44$^b$ | 0.54 |
| Fat (%) | 3.58$^a$ | 6.78$^b$ | 3.70$^a$ | 6.05$^b$ | 0.34 |
| Solid Non-Fat (SNF) (%) | 13.30 | 15.01 | 13.92 | 13.79 | 0.60 |
| Total Solid (TS) (%) | 16.87$^a$ | 21.78$^c$ | 17.62$^{ab}$ | 19.84$^{bc}$ | 0.81 |
| pH | 6.86 | 6.78 | 6,76 | 6.81 | 0.04 |
| Specific Gravity | 1.0285 | 1.0289 | 1.0288 | 1.0288 | 0.0002 |
| Ca (%) | 0.34$^a$ | 0.47$^b$ | 0.56$^c$ | 0.73$^d$ | 0.18 |
| P (%) | 0.23 | 0.27 | 0.29 | 0.26 | 0.24 |

Note: Different superscripts (a,b,c,d) in the same line showed significant differences (P>0.05)

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### *Feed Intake*

The replacement of field grass with various forages (tithonia, cassava leaves, and gamal) and the replacement of tofu waste with PKCC can increase (P<0.05) the dry matter intake (DMI) (Table 5). Treatments B, C, and D revealed better DMI than treatment A. The average organic matter intake (OMI) during the study ranged from 2.23-3.53 Kg/e/h. The OMI in treatment A was significantly (P<0.05) lower than the other treatments. Crude protein intake (CPI) in treatments B, C, and D indicated a higher value than treatment A (P < 0.01). Treatment C which got cassava leaf forage exhibited the highest value (0.91 kg/head/day).

**Table 5.** Feed intake as affected by treatments.

| Parameters (Kg/day) | Treatments A | B | C | D | SEM |
|---|---|---|---|---|---|
| DMI | $2.37^{a}$ | $3.06^{b}$ | $3.85^{c}$ | $3.31^{d}$ | 0.63 |
| OMI | $2.23^{a}$ | $2.81^{b}$ | $3.53^{c}$ | $3.12^{d}$ | 0.64 |
| CPI | $0.39^{a}$ | $0.53^{ab}$ | $0.91^{c}$ | $0.65^{b}$ | 0.64 |

Note: Different superscripts (a.b,c,d) in the same line showed significant differences (P>0.05)

### *Nutrient Digestibility*

The treatment of various forage sources and PKCC concentrates gave a significantly different effect (P<0.05)on the digestibility of dry matter, organic matter, andcrude protein (Table 6). Treatment C got the highest dry matter digestibility (DMD) (76.85%) and organic matter digestibility (OMD) (77.25%) while the lowest wastreatment A (69.43%). The range of crude protein digestibility (CPD) of the treatment was 71.26-86.01%. Also, treatment C got the highest CPD (88.01%) while, treatment A appeared to have the lowest CPD (71.26%).

**Table 6**. The Nutrient digestibility as affected by treatments.

| Parameters (%) | A | B | C | D | SEM |
|---|---|---|---|---|---|
| Dry Matter Digestibility | 67.97$^{a}$ | 73.35$^{b}$ | 76.85$^{c}$ | 68.45$^{a}$ | 0.62 |
| Organic Matter Digestibility | 69.43$^{a}$ | 74.07$^{b}$ | 77.25$^{c}$ | 69.97$^{a}$ | 0.60 |
| Crude Protein Digestibility | 72.19$^{a}$ | 74.83$^{a}$ | 86.01$^{b}$ | 71.26$^{a}$ | 2.10 |

Note: Different superscripts (a,b,c,d) in the same line showed significant differences (P<0.05)

## Discussion

### *Milk Production*

Milk production in this study did not differ (P>0.05) between treatments, but treatments that received various types of forage and PKCC+TW (B, C and D treatments) revealed higher milk production compared A treatments. Milk production is related to the protein value of the ration. Rations B, C, and D contain higher crude protein than ration A (Table 3). In the rumen, crude protein will be converted into $NH_3$. Rumen microbes utilized nitrogen from $NH_3$ for growth (Pazla *et al.*, 2021b). Optimal microbial growth increased microbial activity in fermenting polysaccharides into VFA (Suyitman *et al.*, 2021). VFA is the primary source of energy in ruminants. Optimal energy will optimize livestock productivity in milk production.

Although not statistically significant, milk production increased by replacing field grass with tithonia, gamal, and cassava leave (P>0.05). This proves that tithonia leaves, cassava leaves, gamal, and concentrate (PKCC+TW) can increase ECDG milk production. The higher milk production in treatments B, C, and D was in line with the crude protein content of the rationcontributed from tithonia, cassava leaves, and gamal as well as PKCC+TW. Protein plays a significant role in maintaining mammary gland cells. The production of hormones and enzymes for milk biosynthesis is also strongly influenced by feed protein. Arief *et al.* (2018a) reported ECDG milk production about 1.83 Kg/day which is different from the current study. The difference is due to the type of forage and concentrate used.

### *Milk Quality*

The value of milk protein in this study ranged from 4.89-6.26% and this value are higher than the normal range of 2.75-3% (SNI, 2011). Based on the Thai Agricultural Standard, this milk protein has been categorized as premium milk quality (TAS 6006, 2008). In treatment B and C with tithonia forage, cassava leaves and PKCC+TW showed the highest milk protein. The increase in milk protein content was caused by the combination of forages containing high protein (tithonia and cassava leaves) with PKCC+TW. Ration B and C can increase the supply of amino acids in the rumen to the intestine. Consumption of high-quality ration protein by ECDG is not all degraded in the rumen. Protein also enters the small intestine to be converted into amino acids. Amino acids are absorbed in the small intestine, flow through the circulatory system, and get into theudder. After that, the process is continued on the synthesis of milk protein. The results of this study followJamarun *et al.* (2020a), who said that dairy goats given high crude protein could increase milk protein.

Glucose and galactose are the constituent elements of lactose while the average lactose content in this study is about 3.44-6.73%. According to (SNI, 2011) the lactose content of milk is 2-3%. Also, Ratya *et al.* (2017) reported that the lactose content of ECDG milk was 3.70-3.80. This study indicates that the lactose content ofECDG milk is still in the normal category, and some have the premium category. Treatment B (tithonia + PKCC+TW) resulted in higher levels of lactose (P<0.05) compared to other treatments. Tithonia contains amino acids. The absorbed amino acids in the intestine are broken down into simple sugars. The process occurs in the liver called gluconeogenesis. Gluconeogenesis will increase the glucose level in the blood so that milk lactose level also rises. Zhang *et al.* (2018) stated that glucose is the main precursor in the formation of lactose in milk. High soluble carbohydrates cause the substrate availability needed in the milk lactose synthesis process (Arief *et al.*, 2018b). Lactose in treatment B was not different (P<0.05) with treatment A. Treatment A contained more concentrate, namely tofu waste. Tofu waste is feed ingredients classified as carbohydrates that are easily digested. Carbohydrates are converted to VFA (propionic acid). Propionic acid enters the process ofgluconeogenesis. The blood immobilizes glucose to the udder gland to synthesize lactose in milk (Arief *et al.*, 2020).

The highest milk fat content was found in treatment B (tithonia + PKCC + TW) and was not significantly different (P>0.05) with treatment D (Gamal + PKCC +TW). Treatments A and C were also not critically different (P>0.05) on the fat content. The high-fat content in treatment B was due to the consumption of crude fiber in the ration, which was higher than the other treatments. In addition, the increase milk fat content is also influenced by high feed fat consumption. The fat in the rumen is converted into fatty acids (Makmur *et al.*, 2020). Fatty acids are the precursors in the milk fat formation. ECDG that consume feed with high-fat content tends to have high milk fat.

The SNF value of the ECDG treatment is about 13.30-15.01%. The lowest mean value was in the control treatment (A), namely the ration containing field grass and tofu waste. The highest mean value was indicated by treatment B and followed by treatment C and D. These data indicated that the SNF of treated ECDG milk exceeded the standard. SNI (2011) states that the SNF requirement for milk is 6-8%. The highest SNF was obtained due to high protein and lactose content in treatment B. The rise of SNF level occurs due to the fat content that is not included in that section so that the remaining protein and lactose levels can affect the high percentage produced. The high SNF in treatment B was also influenced by the high BJ value in the treatment compared to other treatments. Utari *et al.* (2012)reported that the SNF of goat's milk-fed with a complete diet ranged from 10.33-11.61%. The difference is due to the high disparity between the dry matter and milk fat content.

Specific gravity is a derived quantity from the quotient of mass and volume. The specific gravity ofmilk can be used to determine the adulteration of milk added by coconut milk, and other ingredients that should not be present in whole milk (Fitriansyah *et al.,* 2014). This study indicates that the average specific gravity of ECDG milk treatment with the highest average was obtained in treatment B, which was 1.0289, while the lowest average specific gravity was obtained in treatmentA, with 1.0285. The statistical analysis results showed that there was no significant difference (P>0.05) betweentreatments on the milk-specific gravity. The range ofspecific gravity of milk was in the normal range, according to (SNI, 2011). Bhattarai (2012) stated that theSpecific gravity of goat's milk is higher than cow's milk. Changes in specific gravity are influenced by the specificgravity of each component of milk consisting of protein, lactose, and fat.

Total solid is a description of the solid content in milk. Treatment B has the highest total solid, 21.78%, while treatment A shows the lowest total solid, which is 16.87% (Table 4). The provision of various types offorage and PKCC+TW on ECDG can produce a total solid that is following (SNI, 2011) which is minimum 10.8%. The administration of various forage and PKCC+TW was significantly different (P<0.05) to the total solid (Table 4).

The low total solid in treatment A was due to the lower nutritional quality in the treatment than other treatments. Treatment A only contained field grass and tofu waste. The difference between the total solid components between treatments occurred due to differences in the use of nutrients in the feed. Similarly, Arief *et al.,* (2021) stated that the total solid depends on the nutrients consumed by livestock. Nutrients will be used as precursors in the formation of solids in milk.

The pH value of milk in this study was 6.76-6.86. The value follows the standard of (TAS 6006, 2008) which is 6.5-6.8. The PH value is an indication of damage to milk. Different pH values can be caused by the content of freshly milked fresh milk such as $CO_2$, phosphate, citrate, and protein. Some of these compounds affect the ability of milk buffer. Milk buffer can inhibit milk's deterioration, which is induced by changes in pH and acidity of milk (Zain, 2013). If there is bacterial activity, the pH value changes to acid (Swadayana *et al.,* 2012). A pH value above 6.7 usually indicates the possibility of mastitis (Legowo *et al.,* 2009).

The content of Ca and P in treatment A which only received feed ingredients from field grass and tofu waste was the lowest value compared to other treatments which got the feed from tithonia forage, cassava leaves, and gamal as well as PKCC+TW. The nutritional quality of the given ration determines the minerals of the milk produced. Pazla *et al.,* (2021c) reported that the Ca and P content of tithonia was richer than field grass, namely 0.99% Ca and 0.33% P. Field grass only contained 0.07% Ca and 0.09% P.

### *Feed Intake*

The replacement of field grass with various forages (tithonia, cassava leaves, and gamal) and the replacement of tofu waste with PKCC can increase (P<0.05) the dry matter intake (DMI) (Table 5). Treatments B, C, and D showed better DMI than treatment A. Treatment A only obtained forage sources from field grass, while other treatments obtained forage in the form of leaves liked by goats. Pazla *et al.,* (2018b) stated that high DMI indicated good palatability of feed ingredients. Good palatability encourages livestock to consume many nutrients. The performance of an animal will be more productive due to nutrition. Palatability is the most influential factor on DMI of livestock. The DMI in this study showed a better percentage when compared to Isah *et al.,* (2015) with DMI values 0.89 kg/head/day. Rosartio *et al.,* (2015) get a DMI which is almost the same as this study, which is 2.73-3.83 kg/head/day. The difference is due to the quality of the forage provided.

The highest DMI was found in treatment C with an average of 3.85 kg/head/day. Giving cassava leaves up to 50% is still palatable for ECDG so that their consumption increases. This is due to the goat's habit of "browsing" in search of food and its preference for leaves. The highest crude protein level in treatment C (Table 3) was also the factor causing the increase in DMI(Table 5). Similarly, Suyitman *et al.,* (2020) state that DMI of feed is influenced by feed digestibility, palatability, crude protein content, and organic matter content.

Treatment A showed the lowest DMI compared to other treatments (P<0.05). The low intake in treatment A was caused by the forage given which was only field grass. Field grass has low nutrient content and palatability compared to forages in other treatments.

The intake pattern of organic matter follows the pattern of DMI. Dry matter is the main component in addition to water content in animal feed ingredients, while organic matter is part of dry matter. The increasein DMI impacted the rise of OMI as reported by (Febrina*et al.*, 2017). The average OMI during the study ranged from 2.23-3.53 Kg/e/h. The OMI in treatment A was significantly (P<0.05) lower than the other treatments. Low OMC is caused by low DMI.

Crude protein intake in treatments B, C, and D (Table 5) showed higher value than treatment A (P < 0.05). Treatment C which got cassava leaf forage revealed the highest value (0.91 kg/head/day). The crude protein content of cassava leaves is also higher than other forages. CPI is strongly influenced by the crude protein content of feed ingredients. In addition, DMI was also the factor causing the rise of CPI in treatment C. Likewise, Arief *et al.* (2021b) stated that the CPI was influenced by the protein content in the ration. The high CPI will affect the high utilization of feed protein for production needs. Giving cassava leaves can increase theCPI.

Moreover, Marwah *et al.*, (2010) found a lower CPI than the CPI in this study, which was 0.34 kg/head/day. The difference is due to the distinct types of forage and concentrates given to ECDG. The ration in recent study was superior because the forage provided had high protein and concentrate with more diverse components.

The anti-nutritional effect of tithonia, cassava, and gamal leaves up to 50% in the ration has not been seen in reducing feed intake. This proves that up to a level of 50%, the provision of tithonia, cassava leaves, and gamal in rations is safe for livestock. Several studies on tithonia, cassava leaves, and gamal added to the ration mix did not affect the productivity and digestibility of ruminantsif the dose was not excessive (Jamarun *et al.*, 2020b).

### *Nutrient Digestibility*

The treatment of various forage sources and PKCC+TW concentrates gave a significantly different effect (P<0.05) on the digestibility of dry matter, organic matter, and crude protein. ECDG that received cassava leaf forage and PKC concentrate revealed higher digestibility than the goats that was given field grass, tithonia, and gamal. This means that cassava leaves can play a role in increasing digestibility (significantly different at P<0.05).

Whether or not the quality of a ration given to livestock can be seen from the percentage of DMD. The higher the DMD, the higher the opportunity for nutrients utilized by livestock for growth and production. Odedire dan Oloidi (2014) obtained lower DMD scores than this study, which was 70.98%. Isah *et al.*, (2015) got the higher DMD which was 754%. The difference in DMDis due to the type and nutritional content of the rations given.

The average DMD value of the treatment ration increased with the provision of tithonia forage, cassava leaves, and PKC concentrate (Table 6). In this case, this is due to the better nutritional content of the ration. The percentage of OMD in this study ranged from 69.43 to 77.25%. Statistical analysis showed that the treatment of various forages and PKC-based concentrates had a significant effect (P 0.05) on OMD. Treatment C got the highest OMD (77.25%) while the lowest was treatment A (69.43%). The OMD value increased along with the rise of the DMD. Jamarun *et al.* (2018c) reported that the pattern of OMD is related with DMD. Most of the dry matter content is digestible organic matter such as carbohydrates, proteins, and fats.

The range of crude protein digestibility of the treatment was 71.26-86.01%. Treatment C got the highest CPD (88.01%) while treatment A got the lowest CPD (71.26%). The chemical composition of feed ingredients dramatically affects the level of digestibility. The quality of the ration is proportional to the digestibility of crude protein. CPD is also associated with the consumption of crude protein. High crude protein consumption will result in high crude proteindigestibility. Putri *et al.* (2021) stated that crude protein digestibility is influenced by microbial protein synthesis. Microbial protein synthesis will increase along with the rise in ration protein (Pazla *et al.*, 2018c).

The treatment of giving various forages and PKC+TW concentrates had a significant effect (P<0.05) on the increase in CPD. This means that the application of tithonia, cassava leaves, and gamal up to 50% could maintain the CPD. Crude protein digestibility is highly dependent on the performance of proteolytic bacteria. Proteolytic bacteria are bacteria that produceextracellular protease enzymes that will break down protein in feed. The significant difference (P<0.05) between treatments was due to different proportions of proteolytic bacteria in each treatment. The CPD in this study was higher than Supriyati and Haryanto (2011), who obtained the CPD of the combination of elephant grass and palm kernel cake of 73.027% - 75.99%. The difference is due to the feed ingredients which are concentrate and forage.

## Conclusion

From the description stated above, the conclusions of the research are as follows:

1. Replacement of field grass with various forage sources and replacement of tofu waste with concentrate based palm kernel cake can increase feed consumption and digestibility
2. Replacement of field grass with various forage sources and replacement of tofu waste with concentrate-based palm kernel cake increases protein, lactose, fat, and calcium of milk but did not affect solid nonfat, total solids, pH, and specific gravity of milk.

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## Author Contribution

**Arief:** Designed the research plan, organized and supervised the study.

**Roni Pazla:** Conducted the research, analyzed data and contributed to the writing of the manuscript.

## Conflict of Interest

The authors declare that they have no conflict of interests.

## Ethics

This article is original and has never been published before. The author has also confirmed to all authors involved in this study to read and agree to the contents of this article and that there are no ethical issues involved.

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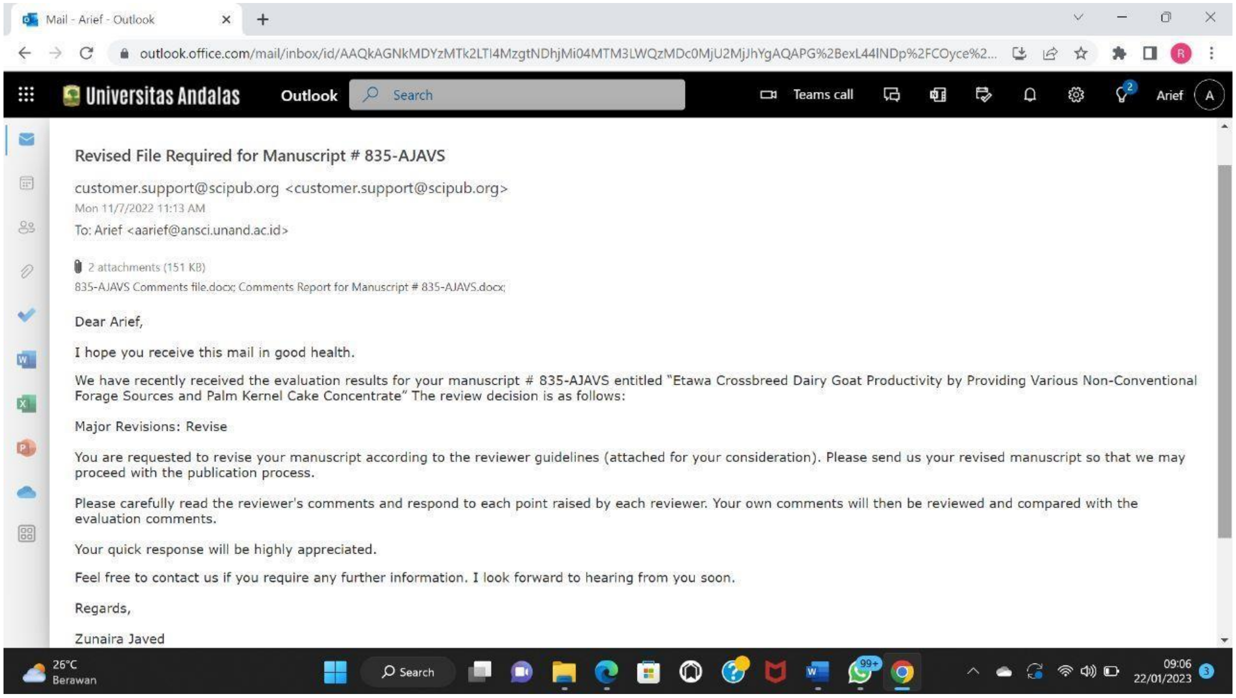
## Email Revisi Ke-1 Dari Jurnal (7 November 2022)



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We have recently received the evaluation results for your manuscript # 835-AJAVS entitled "Etawa Crossbreed Dairy Goat Productivity by Providing Various Non-Conventional Forage Sources and Palm Kernel Cake Concentrate" The review decision is as follows:

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Naskah Revisi Ke-1

American Journal of Animal and Veterinary Science

Original Research Paper

# Productive Traits of Etawa Crossbred Goats with Non-Conventional Forages and Palm Concentrates

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**Abstract -** Using Tithonia (*Tithonia diversifolia*), Cassava leaves (*Manihot utilisima*), and Gamal (*Gliricidia sepium*) as an alternative fiber and palm concentrate as an alternative protein is one of the ways to do this effective feeding strategy under a limited supply or lack of feed sources for Etawa Crossbreed Dairy Goats (ECDG)**.**This research aimed to study the productive traits and milk quality of ECDG fed on several sources of forage with palm kernel cake concentrate (PKCC). The experimental design was completely randomized with four treatments of feed formulation. Treatment formulations were as follows: A. 50% tofu waste (TW) + 50% field grass (control); B. 25% TW + 25% PKCC + 50% tithonia (*Tithonia diversifolia*); C. 25% TW+ 25% PKCC + 50% cassava leaves (*Manihot utilisima*); D. 25% TW + 25% PKCC + 50% Gamal (*Gliricidia sepium*). The parameters measured were dry matter intake (DMI), organic matter intake (OMI), crude protein intake (CPI), dry matter digestibility (DMD), organic matter digestibility (OMD), crude protein digestibility (CPD), milk production, and milk quality (protein, lactose, fat, Solid Non-fat (SNF), Total Solid (TS), pH, specific gravity, and minerals such as calcium and phosphorus). The results showed that the treatment hadno significant effect on milk production, SNF, pH, specific gravity, and P. However, the effects were significant ($P<0.05$) on parameters such as DMI, OMI, CPI, DMD, OMD, CPD, protein, lactose, fat, TS, and Ca of milk. It can be concluded that the replacement of field grass with forage sources such as Tithonia, Cassava leaves, and Gamal and the replacement of tofu waste with concentrate-based palm kernel cake could increase feed intake, digestibility, protein, lactose, fat, and calcium of milk.

**Keywords:** Goat, Forage, Milk, Nutrition, Palm concentrate.

## Introduction

Forage such as elephant grass is the main feed for ruminants to provide crude fiber. Other unconventional forage sources are Tithonia (*Tithonia diversifolia*), Cassava leaves (*Manihot utilisima*), and Gamal (*Gliricidia sepium*) were suggested. Tithonia is a shrub or weed-like plant that grows a lot in empty land, roadsides, and rice fields. In West Sumatra, tithonia is also known as the paitan plant because of its bitter leaves(Pazla *et al.*, 2021a). Tithonia plants have not been widely used as a source of organic matter, fertilizer, or animal feed ingredients. However, tithonia is quite favored by livestock because of its high protein content



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of up to 22.98% (Jamarun *et al.,* 2019). Also, Cassava leaves and Gamal are nutritious foraged ingredients that are useful for livestock.

Furthermore, livestock needs concentrated feed ingredients for energy. The prices of concentrate ingredients, especially corn, are expensive. Therefore, it is necessary to look for alternative feed ingredients with abundant availability and quality to reduce dependence on imported feed ingredients. One of the concentrate feed ingredients is a by-product of the palm oil processing industry, namely palm kernel cake (PKC). Viewed from the production aspect, 60% of the total palm oil industry products are by-products. PKC is useful as an alternative feed ingredient for livestock because it has good nutritional composition and great potential as a source of concentrated feed ingredients for livestock (Arief *et al.,* 2019a).

In addition to dairy goats, livestock that can be developed as milk-producing is Etawa Crossbred Dairy Goats (ECDG). The ECDG crosses between Etawa goats and Indonesian Kacang goats. The advantage of ECDGis that they have good adaptability to the different environmental macroclimatic conditions in Indonesia. ECDG are dual-purpose type goats that have good reproductive characteristics and better nutritional milk content than cow's milk (Arief *et al.,* 2019b). ECDG is raised for milk production, especially in Indonesia (Arief *et al.,* 2019b). Goat's milk contains minerals such as Ca, P, and Mg which are higher than cow's and human milk. The high content of medium-chain fatty acids is beneficial for the body because it is rapidly oxidized by the liver and induces a full effect (Vaquil and Rathee, 2017). Besides, goat's milk has medicinal properties that can cure various diseases such as asthma and tuberculosis (Pal U *et al.,* 2011).

Research on the use of various forage sources combined with the provision of by-products from the palm oil industry and tofu waste as feed ingredients for lactating ECDG concentrates has never been carried out. If this potential is explored properly, non-conventional forage sources and the palm oil industry will play a significant role in providing animal feed, especially dairy goats, which are useful for supporting food self-sufficiency programs, especially milk in Indonesia (Pazla, 2018a). This research aimed to study the productive traits and milk quality of ECDG fed on several sources of forage with palm kernel cake concentrate (PKCC).

## Materials and Methods

### *Ethical Approval*

This experiment has referred to research ethics using livestock based on the Republic of Indonesia government law number 18 of 2009 (Section 66), which addressed animal keeping, raising, killing, and proper treatment and care.

### *Experimental Design and duration*

This research was conducted at an ECDG livestock company in Payakumbuh, West Sumatra, Indonesia (-0.2330638,100.6268024). There were 16 ECDGs in the second month of lactation used in this research. The selected ECDG at 1-1.5 years and 58-60 kg. The environmental temperature condition around the cage is 26°C with relative humidity ranging from 45-50%. The system for raising livestock, feeding, and drinking water are carried out intensively, where all the livestock needs are available in cages with adequate water sources and fulfill drinking water requirements for livestock. Likewise, the cage's air circulation, ventilation, and lighting systems have met the requirements of a good livestock business.

The livestock business has been managed according to Good Farming Practice procedures, especially regarding maintenance systems such as the cleanliness ofthe cage and cage environment and handling of milk after milking. Stables, equipment, and livestock are always cleaned to produce healthy, hygienic milk.Treatment is done if there are cases of disease that attack livestock. Cleanliness of stables, livestock, and equipment is always routinely carried out daily so livestock is protected from disease. To maintain the health and productivity of livestock, breeders administer deworming drugs orally once every six months under the brand name Verm O. Specifically, regarding animal welfare, breeders have implemented and paid attention to the principles of animal welfare in their livestock, especially regarding animal freedom provisions, namely freedom from hunger and thirst, discomfort, pain, injury, and disease, and freedom from normal express behavior.

This experiment used a 4 x 4 completely randomized design determined by four treatments of feed formulation as follows: A. 50% tofu waste (TW) + 50% Field grass (control); B. 25% TW + 25% Kernel Cake Concentrate (PKCC) + 50% tithonia; C. 25% TW+ 25% PKCC + 50% Cassava leaves; D.25% TW + 25% PKCC + 50% Gamal for a total of 16 experimental units. ECDGs were placed in individual cages with a size of 1.25 m x1.00 m. The experimental cage was given disinfectant (anti-microorganism) to inhibit and kill microorganism and all ECDG were given deworming before the study started. All ECDGs were confirmed not to have mastitis. The experiment was carried out for 50 days consisting of 30 days of the adaptation period, 15 days of the preliminary period, and 5 days of the collecting period.

**Table 1**. The nutritional content of each feed ingredient.

| Nutrient (%) | Feedstuff | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Fields grass | T | CL | G | Rice bran | Tofu waste | PKC | Corn |
| Dry Matter | 23.29 | 25.57 | 31.10 | 21.42 | 87.80 | 28.40 | 91.83 | 85.80 |
| Organic Matter | 92.41 | 84.01 | 89.85 | 94.85 | 90.80 | 97.67 | 91.41 | 99.10 |
| Protein | 10.23 | 22.98 | 27.15 | 19.11 | 10.72 | 20.11 | 12,36 | 07.7 |
| Crude Fiber | 25.44 | 18.17 | 19.12 | 19.75 | 11.60 | 19.00 | 26.68 | 02.44 |
| Extract Ether | 3.64 | 04.71 | 3.52 | 2.98 | 08.73 | 01.25 | 8,23 | 03.50 |
| NFE | 53.1 | 38.15 | 39.26 | 53.01 | 59.75 | 57.31 | 44.14 | 85.46 |
| NDF | 67.20 | 55.03 | 56.13 | 46.33 | 55.13 | 59.28 | 66.70 | 49.96 |
| TDN | 58.65 | 62.60 | 79.21 | 67.60 | 66.63 | 74.61 | 65.40 | 81.90 |

Note: T= Tithonia, CL = Cassava leaf, G=Gamal, PKC = Palm Kernel Cake, NFE = Nitrogen Free Extract, NDF =Neutral Detergent Fiber, TDN = Total Digestible Nutrient

**Table 2**. The composition and nutrients of palm kernel cake concentrate (%DM)

| Feed Ingredients | Level (%) |
|---|---|
| Palm kernel cake | 40.00 |
| Rice bran | 20.00 |
| Corn | 9.00 |
| Tofu waste | 30.00 |
| Mineral | 1.00 |
| **Nutrient** | **Percentage (%)** |
| Dry matter | 91.84 |
| Ash | 9.88 |
| Crude protein | 16.88 |
| Crude fiber | 13.22 |
| NFE | 55.06 |
| NDF | 62.84 |
| TDN | 66.36 |

Note: NFE = Nitrogen Free Extract, NDF =Neutral Detergent Fiber, TDN = Total Digestible Nutrient

**Table 3**. Composition of treatments ration (%)

| Feed Materials | Treatments | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Field grass | 50 | 0 | 0 | 0 |
| Tithonia | - | 50 | 0 | 0 |
| Cassava | - | - | 50 | 0 |
| Gamal | - | - | 0 | 50 |
| PKCC | - | 25 | 25 | 25 |
| Tofu waste | 50 | 25 | 25 | 25 |
| Total | 100 | 100 | 100 | 100 |
| Nutrient composition | | | | |
| Dry Matter | 25.85 | 42.85 | 45.61 | 40.77 |
| Ash | 4.96 | 11.05 | 8.13 | 5.63 |
| Protein | 15.17 | 20.74 | 22.82 | 18.80 |
| Crude Fiber | 14.48 | 17.14 | 18.02 | 17.93 |
| NFE | 55.21 | 47.17 | 47.72 | 54.60 |
| NDF | 63.24 | 58.05 | 58.60 | 53.70 |
| TDN | 66.63 | 66.54 | 74.85 | 69.04 |

Note: NFE = Nitrogen Free Extract, NDF =Neutral Detergent Fiber, TDN = Total Digestible Nutrient

The experimental ration consisted of forage and concentrate in a ratio of 50:50. The ration was given at 30.5% of body weight-based dry matter (NRC, 2007). Drinking water was available *ad libitum*. The nutritional contents of each feed ingredient are presented in Table 1. The composition and nutritional contents of palm kernel cake-based concentrates are presented in Table 2. The composition and nutritional contents of the experimental rations are explained in Table 3. Proximate analysis of feed ingredients (dry matter, ash, protein, extract ether, and crude fiber) was carried out following (AOAC, 2005). NDF was determined following (Goering and Van Soest, 1970). TDN was estimated with the following formula (Moran, 2005):

$$TDN = 5.31 + 0.412\ CP\% + 0.249\ CF\% + 1.444\ EE\% + 0.937\ NFE\%$$

Where: CP = crude protein; CF = crude fiber; EE = extract ether; NFE = nitrogen free extract

### *Collection of Fecal Samples*

The sewage collection from the ECDG was carried out for 5 days from the 46$^{th}$ day to the 50$^{th}$ day. The dirt was weighed every day at 8 am (the weight of fresh dirt).Then 200 grams of dirt was taken as a sample to analyze the dry matter, ash, and crude protein content. The samples were oven to 60°C for 8 hours and then weighed(dry weight). Before analysis in the laboratory, goat hair attached to the manure was removed.

### *Milk Sample Collection*

Every day, the milk production of each experimental animal was weighed and recorded. Milk samples were taken 2 times during the study for quality testing asmuch as 300 mL per treatment goat. Before sampling,the nipples were cleaned so that the dirt that sticks out can be lost and does not contaminate the milk. Then,milk sample was taken and stored in a cool box to avoid microbial contamination. Finally, milk samples were taken to the laboratory for analysis.

*Parameters Measured*

The variables measured were dry matter intake (DMI), organic matter intake (OMI), crude protein intake(CPI), dry matter digestibility (DMD), organic matter digestibility (OMI), Crude protein digestibility (CPI), milk production, and milk quality parameters such as milk protein, lactose, milk fat, total solid (TS), Solid Non-Fat (SNF), pH, BJ, and Ca and P mineral. Protein, lactose, and fat were measured using the method of (AOAC, 2005), SNF and TS were measured using lactoscan MCC50, pH was measured using a pH meter digital HI9807-phep, Singapura, while Specific Grafity was measured using a Lactodensimeter merk Funke Gerber Germany.

### *Statistical Analysis*

Experimental data were analyzed using the analysis of variance (ANOVA) with a completely randomized design (Steel and Torrie, 2002) using SPSS software version 20. Parameters mean showed statistical differences in probabilities level of P<0.05 compared using the Duncan multiple range tests. The statistical model and experimental design were as foloows:

$$Y\text{ij} = \mu + M\text{i} + \text{sij}$$

Where**,** *Yij* denotes the observation variable, $\mu$ denotes the overall mean, *M* denotes the effect of treatments and $\varepsilon ij$ denotes the residual effect.

## Results

### *Milk Production*

Optimal milk production and quality are the goal and hope of dairy goat farmers. The quality of feed greatly determines the optimal production and quality of milk. Milk production in this study did not differ between treatments (P>0.05), but treatments that received various types of forage (Tithonia, Cassava leaves, and Gamal) and PKCC showed higher milk production (Fig. 1).

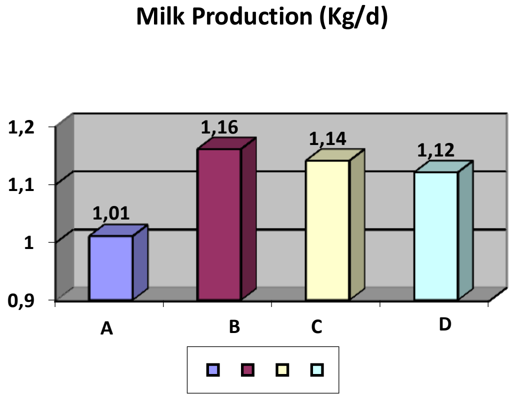


Fig.1: Milk production as affected by treatments

### *Milk Quality*

The results on the quality of ECDG goat milk showed that treatment C had the highest milk protein contents (Table 4) which was not significantly different from treatments B and D. Treatment B resulted in higher levels of lactose (P<0.05). The highest milk fat content was found in treatment B which was not significantly different from treatment D. The highest SNF was obtained due to the high protein and lactose contents in treatment B. The statistical analysis showed that there was no significant difference between treatments on the specific gravity of milk. Treatment B had the highest total solid, 21.78%, and treatment A exhibited the lowest total solid up to 16.87%. The pH value of milk in this study was 6.76-6.86. The contents of Ca and P in treatment A expose the lowest value when compared to treatments B, C, and D, which received ingredients from Tithonia forage, Cassava leaves, and Gamal, as well as PKCC.

**Table 4**. Milk quality of the different experimental groups.

| Parameters | Treatments | | | | SEM |
|---|---|---|---|---|---|
| | A | B | C | D | |
| Protein (%) | 4.89$^{a}$ | 5.99$^{b}$ | 6.26$^{b}$ | 6.01$^{b}$ | 0.25 |
| Lactose (%) | 5.58$^{a}$ | 6.73$^{a}$ | 3.55$^{b}$ | 3.44$^{b}$ | 0.54 |
| Fat (%) | 3.58$^{a}$ | 6.78$^{b}$ | 3.70$^{a}$ | 6.05$^{b}$ | 0.34 |
| Solid Non-Fat (SNF) (%) | 13.30 | 15.01 | 13.92 | 13.79 | 0.60 |
| Total Solid (TS) (%) | 16.87$^{a}$ | 21.78$^{c}$ | 17.62$^{ab}$ | 19.84$^{bc}$ | 0.81 |
| pH | 6.86 | 6.78 | 6.76 | 6.81 | 0.04 |
| Specific Gravity (g/cm$^{3}$) | 1.0285 | 1.0289 | 1.0288 | 1.0288 | 0.0002 |
| Ca (%) | 0.34$^{a}$ | 0.47$^{b}$ | 0.56$^{c}$ | 0.73$^{d}$ | 0.18 |
| P (%) | 0.23 | 0.27 | 0.29 | 0.26 | 0.24 |

Note: Different superscripts (a,b,c,d) in the same line showed significant differences (P>0.05)

### *Feed Intake*

The replacement of field grass with various forages (Tithonia, Cassava leaves, and Gamal) and the replacement of tofu waste with PKCC could increase (P<0.05) the dry matter intake (DMI) (Table 5). Treatments B, C, and D revealed better DMI. The average organic matter intake (OMI) during the study ranged from 2.23-3.53 Kg/e/h. The OMI in treatment A was significantly (P<0.05) lower than the other treatments. Crude protein intake (CPI) in treatments B, C, and D indicated a higher value (P < 0.05). Treatment C exhibited the highest value (0.91 kg/head/day).

**Table 5.** Feed intake of the different experimental groups.

| Parameters (Kg/day) | Treatments A | B | C | D | SEM |
|---|---|---|---|---|---|
| DMI | 2.37$^{a}$ | 3.06$^{b}$ | 3.85$^{c}$ | 3.31$^{d}$ | 0.63 |
| OMI | 2.23$^{a}$ | 2.81$^{b}$ | 3.53$^{c}$ | 3.12$^{d}$ | 0.64 |
| CPI | 0.39$^{a}$ | 0.53$^{ab}$ | 0.91$^{c}$ | 0.65$^{b}$ | 0.64 |

Note: Different superscripts (a.b,c,d) in the same line showed significant differences (P>0.05)

### *Nutrient Digestibility*

The treatment of various forage sources and PKCC concentrates gave a significantly different effect (P<0.05) on the digestibility of dry matter, organic matter, and crude protein (Table 6). Treatment C revealed the highest dry matter digestibility (DMD) (76.85%) and organic matter digestibility (OMD) (77.25%) while the lowest was treatment A (69.43%). The range of crude protein digestibility (CPD) of the treatment was 71.26-86.01%. Also, treatment C showed the highest CPD (88.01%) while, treatment A appeared to have the lowest CPD (71.26%).

**Table 6**. Nutrient digestibility of the different experimental groups.

| Parameters (%) | Treatments A | B | C | D | SEM |
|---|---|---|---|---|---|
| Dry Matter Digestibility | 67.97$^{a}$ | 73.35$^{b}$ | 76.85$^{c}$ | 68.45$^{a}$ | 0.62 |
| Organic Matter Digestibility | 69.43$^{a}$ | 74.07$^{b}$ | 77.25$^{c}$ | 69.97$^{a}$ | 0.60 |
| Crude Protein Digestibility | 72.19$^{a}$ | 74.83$^{a}$ | 86.01$^{b}$ | 71.26$^{a}$ | 2.10 |

Note: Different superscripts (a,b,c,d) in the same line showed significant differences (P<0.05)

## Discussion

### *Milk Production*

Milk production in this study did not differ between treatments, but treatments that received various types of forage and PKCC+TW (B, C, and D) revealed higher milk production. Milk production is related to the proteinvalue of the ration. Rations B, C, and D contained highercrude protein. In the rumen, crude protein will be converted into NH$_3$. Rumen microbes utilized nitrogen from NH$_3$ for growth (Pazla *et al.*, 2021b). Optimal microbial growth increased microbial activity in fermenting polysaccharides and converted them into VFA (Suyitman *et al.*, 2021). VFA is the primary source of energy in ruminants. Optimal energy will optimize livestock productivity in milk production.

Although not statistically significant, milk production increased by replacing field grass with Tithonia, Gamal, and Cassava leave. This proves that Tithonia leaves, Cassava leaves, Gamal, and concentrate (PKCC+TW) could increase ECDG milk production. The higher milk production in treatments B, C, and D was in line with the crude protein content of the ration contributed from Tithonia, Cassava leaves, and Gamal, as well as PKCC+TW. Protein plays a significant role in maintaining mammary gland cells. The production of hormones and enzymes for milk biosynthesis is also strongly influenced by feed protein. Arief *et al.* (2018a) reported ECDG milk production of about 1.83 Kg/day which is different from the current study. The difference is due to the type of forage and concentrates used.

### *Milk Quality*

The value of milk protein in this study ranged from 4.89-6.26% and this value is higher than the normal range of 2.75-3% (SNI, 2011). Based on the Thai Agricultural Standard, this milk protein has been categorized as premium milk quality (TAS 6006, 2008). Treatments B and C with Tithonia forage, Cassava leaves, and PKCC+TW showed the highest milk protein.

The increase in milk protein contents was caused by the combination of forages containing high protein (Tithonia and Cassava leaves) with PKCC+TW. Rations B and C can increase the supply of amino acids in the rumen to the intestine. Consumption of high-quality ration protein by ECDG is not all degraded in the rumen. Protein also enters the small intestine to be converted into amino acids. Amino acids are absorbed in the small intestine, flow through the circulatory system, and get into the

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udder. After that, the process continued with the synthesis of milk protein. The results of this study follow Jamarun *et al.* (2020a), who stated that dairy goats given high crude protein could increase milk protein.

Glucose and galactose are the constituent elements of lactose while the average lactose content in this study is about 3.44-6.73%. According to (SNI, 2011) the lactose content of milk is 2-3%. Ratya *et al.* (2017) reported that the lactose content of ECDG milk was 3.70-3.80. This study indicated that the lactose content of ECDG milk is still in the normal category, and some have the premium category. Treatment B (Tithonia + PKCC+TW) resulted in higher levels of lactose. Tithonia contains amino acids. The absorbed amino acids in the intestine were broken down into simple sugars. Gluconeogenesis in the liver will increase the glucose level in the blood so that the milk lactose level also rises. Zhang *et al.* (2018) stated that glucose is the main precursor in the formation of lactose in milk. High-soluble carbohydrates cause the substrate availability needed in the milk lactose synthesis process (Arief *et al.,* 2018b). Lactose in treatment B was not different from treatment A. Treatment A contained more concentrate (tofu waste). Tofu waste is feed ingredients classified as carbohydrates that are easily digested. Carbohydrates are converted to VFA (propionic acid). Propionic acid enters the process of gluconeogenesis. The blood immobilizes glucose in the udder gland to synthesize lactose in milk (Arief *et al.,* 2020).

The highest milk fat content was found in treatment B (Tithonia + PKCC + TW) and was not significantly different from treatment D (Gamal + PKCC +TW). Treatments A and C were also not critically different in the fat contents. The high-fat contents in treatment B were due to the consumption of crude fiber in the ration, which was higher than the other treatments. In addition, the increased milk fat contents are also influenced by high feed fat consumption. The fat in the rumen is converted into fatty acids (Makmur *et al.*, 2020). Fatty acids are the precursors in milk fat formation. ECDGs that consume feed with high-fat content tend to have high milk fat.

The SNF value of the ECDG treatment is about 13.30-15.01%. The lowest mean value was in the control treatment (A. The highest mean value was indicated by treatment B and followed by treatments C and D. These data indicated that the SNF of treated ECDG milk exceeded the standard. SNI (2011) stated that the SNF requirement for milk is 6-8%. The highest SNF was obtained due to the high protein and lactose content in treatment B. The rise of SNF level occurs due to the fat content that is not included in that section so the remaining protein and lactose levels can affect the high percentage produced. The high SNF in treatment B was also influenced by the high BJ value in the treatment compared to other treatments. Utari *et al.* (2012)reported that the SNF of goat milk-fed with a complete diet ranged from 10.33-11.61%. The difference is due to the high disparity between the dry matter and milk fat content.

Specific gravity is a derived quantity from the quotient of mass and volume. The specific gravity ofmilk can be used to determine the adulteration of milk added by coconut milk, and other ingredients that should not be present in whole milk (Fitriansyah *et al.*, 2014). This study indicated that the average specific gravity of ECDG milk treatment with the highest average was obtained in treatment B, while the lowest average specific gravity was obtained in treatment A. The statistical analysis results showed that there was no significant between treatments on the milk-specific gravity. The specific gravity of milk was in the normal range, according to (SNI, 2011). Bhattarai (2012) stated that the specific gravity of goat's milk is higher than cow's milk. Changes in specific gravity are influenced by the specific gravity of each component of milk consisting of protein, lactose, and fat.

Total solid is a description of the solid content in milk. Treatment B has the highest total solid, while treatment A shows the lowest total solid. The provisionof various types of forage and PKCC+TW on ECDG canproduce a total solid that is following (SNI, 2011) which is a minimum of 10.8%. The administration of various forage and PKCC+TW was significantly different ($P<0.05$) from the total solid.

The low total solid in treatment A was due to the lower nutritional quality in the treatment than other treatments. Treatment A only contained field grass and tofu waste. The difference between the total solid components between treatments occurred due to differences in the use of nutrients in the feed. Similarly, Arief *et al.,* (2021) stated that the total solid depends on the nutrients consumed by livestock. Nutrients will be used as precursors in the formation of solids in milk.

The pH value of milk in this study was 6.76-6.86. The value follows the standard of (TAS 6006, 2008) which is 6.5-6.8. The PH value is an indication of damage to milk. Different pH values can be caused by the content of freshly milked fresh milk such as $CO_2$, phosphate, citrate, and protein. Some of these compounds affect the ability of milk buffer. Milk buffer can inhibit milk's deterioration, which is induced by changes in the pH and acidity of milk (Zain, 2013). If there is bacterial activity, the pH value changes to acid (Swadayana *et al.,* 2012). A pH value above 6.7 usually indicates the possibility of mastitis (Legowo *et al.,* 2009).

The content of Ca and P in treatment A which only received feed ingredients from field grass and tofu waste was the lowest value. The nutritional quality of the given ration determines the minerals of the milk produced. Pazla *et al.,* (2021c) reported that the Ca and P content of Tithonia was richer than field grass, namely 0.99% Ca and 0.33% P, while field grass only contained 0.07% Ca and 0.09% P.

### *Feed Intake*

The replacement of field grass with various forages (Tithonia, Cassava leaves, and Gamal) and the replacement of tofu waste with PKCC can increase the dry matter intake (DMI). Treatments B, C, and D showed better DMI. Pazla *et al.,* (2018b) stated that high DMI indicated good palatability of feed ingredients. Good palatability encourages livestock to consume many nutrients. The performance of an animal will be more productive due to nutrition. Palatability is the most influential factor in the DMI of livestock. The DMI in this study showed a better percentage when compared to Isah *et al.,* (2015) with DMI values of 0.89 kg/head/day.

Rosartio *et al.,* (2015) get a DMI that is almost the same as this study, which is 2.73-3.83 kg/head/day. The difference is due to the quality of the forage provided.

The highest DMI was found in treatment C with an average of 3.85 kg/head/day. Giving Cassava leaves up to 50% is still palatable for ECDG so their consumption increases. This is due to the goat's habit of "browsing" in search of food and its preference for leaves. The highest crude protein level in treatment C was also the factor causing the increase in DMI. Similarly, Suyitman *et al.,* (2020) state that the DMI of feed is influenced by feed digestibility, palatability, crude protein contents, and organic matter contents.

Treatment A showed the lowest DMI. The low intake in treatment A was caused by the forage given. Field grass has low nutrient contents and palatability compared to forages in other treatments.

The intake pattern of organic matter follows the pattern of DMI. Dry matter is the main component in addition to water content in animal feed ingredients, while organic matter is part of dry matter. The increasein DMI impacted the rise of OMI as reported by (Febrina*et al.,* 2017). The average OMI during the study ranged from 2.23-3.53 Kg/e/h. The OMI in treatment A was significantly lower than in the other treatments. LowOMC is caused by low DMI.

Crude protein intake in treatments B, C, and D showed a higher value. Treatment C which got Cassava leaf forage revealed the highest value (0.91 kg/head/day). The crude protein content of Cassava leaves is also higher than other forages. CPI is strongly influenced by the crude protein content of feed ingredients. In addition, DMI was also the factor causing the rise of CPI in treatment C. Likewise, Arief *et al.* (2021b) stated that the CPI was influenced by the protein content in the ration. The high CPI will affect the high utilization of feed protein for production needs. Giving Cassava leaves can increase the CPI.

Marwah *et al.,* (2010) found a lower CPI than the CPI in this study, which was 0.34 kg/head/day. The difference is due to the distinct types of forage and concentrates given to ECDG. The ration in a recent study was superior because the forage provided had high protein and concentrate with more diverse components.

The anti-nutritional effect of Tithonia, Cassava, and Gamal leaves up to 50% in the ration has not been seen in reducing feed intake. This proves that up to a level of 50%, the provision of Tithonia, Cassava, and Gamal in rations is safe for livestock. Several studies on Tithonia, Cassava, and Gamal added to the ration mix did notaffect the productivity and digestibility of ruminants if the dose was not excessive (Jamarun *et al.,* 2020b).

### *Nutrient Digestibility*

The treatment of various forage sources and PKCC+TW concentrates gave a significantly different effect on the digestibility of dry matter, organic matter, and crude protein. ECDG that received Cassava leaf forage and PKC concentrate revealed higher digestibility than the goats that were given field grass, Tithonia, and Gamal. This means that cassava leaves can play a role in increasing digestibility.

Whether or not the quality of a ration given to livestock can be seen from the percentage of DMD. The higher the DMD, the higher the opportunity for nutrients utilized by livestock for growth and production. Odedire dan Oloidi (2014) obtained lower DMD scores than this study, which was 70.98%. Isah *et al.,* (2015) got the higher DMD which was 754%. The difference in DMD is due to the type and nutritional content of the rations given.

The average DMD value of the treatment ration increased with the provision of tithonia forage, Cassava leaves, and PKC concentrate. In this case, this is due to the better nutritional content of the ration. The percentage of OMD in this study ranged from 69.43 to 77.25%. The treatment of various forages and PKC- based concentrates had a significant effect on OMD. Treatment C got the highest OMD (77.25%) while the lowest was treatment A (69.43%). The OMD value increased along with the rise of the DMD. Jamarun *et al.* (2018c) reported that the pattern of OMD is related to DMD. Most of the dry matter content is digestible organic matter such as carbohydrates, proteins, and fats.

The range of crude protein digestibility of the treatment was 71.26-86.01%. Treatment C got the highest CPD (88.01%) while treatment A got the lowest CPD (71.26%). The chemical composition of feed ingredients dramatically affects the level of digestibility. The quality of the ration is proportional to the digestibility of crude protein. CPD is also associated with the consumption of crude protein. High crude protein consumption will result in high crude proteindigestibility. Putri *et al.* (2021) stated that crude protein digestibility is influenced by microbial protein synthesis. Microbial protein synthesis will increase along with the rise in ration protein (Pazla *et al.,* 2018c).

The treatment of giving various forages and PKC+TW concentrates had a significant effect on the increase in CPD. This means that the application of Tithonia, Cassava, and Gamal up to 50% could maintain the CPD. Crude protein digestibility is highly dependent on the performance of proteolytic bacteria. Proteolytic bacteria are bacteria that produce extracellular protease enzymes that will break down protein in feed. The significant difference between treatments was due to different proportions of proteolytic bacteria in each treatment. The CPD in this study was higher than Supriyati and Haryanto (2011), who obtained a CPD of the combination of elephant grass and palm kernel cake of 73.027% - 75.99%. The difference is due to the feed ingredients which are concentrate and forage.

## Conclusion

Replacement of field grass with various forage sources and replacement of tofu waste with concentrate- based palm kernel cake could increase feed consumption and digestibility, as well as increases protein, lactose, fat,and calcium of milk but did not affect solid nonfat, total solids, pH, and specific gravity of milk.

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## Author Contribution

**Arief:** Designed the research plan, and organized and supervised the study.

**Roni Pazla:** Conducted the research, analyzed data, and contributed to the writing of the manuscript.

## Conflict of Interest

The authors declare that they have no conflict of interest.

## Ethics

This article is original and has never been published before. The author has also confirmed to all authors involved in this study to read and agree to the contents of this article and that there are no ethical issues involved.

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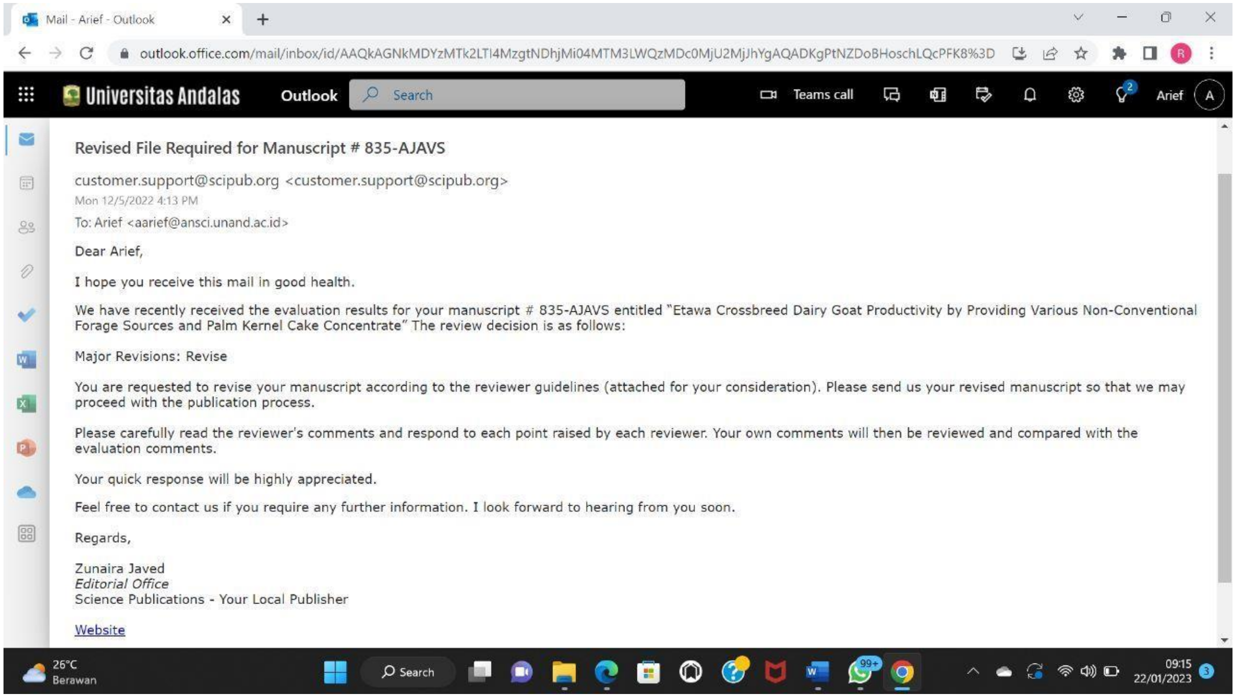
# Email Revisi Ke-2 dari Jurnal (5 Desember 2022)



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Dear Arief,

I hope you receive this mail in good health.

We have recently received the evaluation results for your manuscript # 835-AJAVS entitled "Etawa Crossbreed Dairy Goat Productivity by Providing Various Non-Conventional Forage Sources and Palm Kernel Cake Concentrate" The review decision is as follows:

Major Revisions: Revise

You are requested to revise your manuscript according to the reviewer guidelines (attached for your consideration). Please send us your revised manuscript so that we may proceed with the publication process.

Please carefully read the reviewer's comments and respond to each point raised by each reviewer. Your own comments will then be reviewed and compared with the evaluation comments.

Your quick response will be highly appreciated.

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*American Journal of Animal and Veterinary Science*

Original Research Paper

# Milk Production and Quality of Etawa Crossbred Goats with Non-Conventional Forages and Palm Concentrates

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**Abstract -** Using Tithonia (*Tithonia diversifolia*), Cassava leaves (*Manihot utilisima*), and Gamal (*Gliricidia sepium*) as an alternative fiber and palm concentrate as an alternative protein is one of the ways to do this effective feeding strategy under a limited supply or lack of feed sources for Etawa Crossbreed Dairy Goats (ECDG)**.**This research aimed to study the productive traits and milk quality of ECDG fed on several sources of forage with palm kernel cake concentrate (PKCC). The experimental design was completely randomized with four treatments of feed formulation. Treatment formulations were as follows: A. 50% tofu waste (TW) + 50% field grass (control); B. 25% TW + 25% PKCC + 50% tithonia (*Tithonia diversifolia*); C. 25% TW+ 25% PKCC + 50% cassava leaves (*Manihot utilisima*); D. 25% TW + 25% PKCC + 50% Gamal (*Gliricidia sepium*). The results showed were significant ($P<0.05$) on parameters such as DMI, OMI, CPI, DMD, OMD, CPD, protein, lactose, fat, TS, and Ca of milk. It can be concluded that the replacement of field grass with forage sources such as Tithonia, Cassava leaves, and Gamal and the replacement of tofu waste with concentrate-based palm kernel cake could increase feed intake, digestibility, protein, lactose, fat, and calcium of milk.

**Keywords:** Goat, Forage, Milk, Nutrition, Palm concentrate.

## Introduction

Forage such as elephant grass is the main feed for ruminants to provide crude fiber. Other unconventional forage sources are Tithonia (*Tithonia diversifolia*), Cassava leaves (*Manihot utilisima*), and Gamal (*Gliricidia sepium*) were suggested. Tithonia is a shrub or weed-like plant that grows a lot in empty land, roadsides, and rice fields. In West Sumatra, tithonia is also known as the paitan plant because of its bitter leaves(Pazla *et al.*, 2021a). Tithonia plants have not been widely used as a source of organic matter, fertilizer, or animal feed ingredients. However, tithonia is quite favored by livestock because of its high protein content of up to 22.98% (Jamarun *et al.*, 2019). Also, Cassava leaves and Gamal are nutritious foraged ingredients that are useful for livestock.

Furthermore, livestock needs concentrated feed ingredients for energy. The prices of concentrate ingredients, especially corn, are expensive. Therefore, it is necessary to look for alternative feed ingredients with abundant availability and quality to reduce dependence on imported feed ingredients. One of the concentrate feed ingredients is a by-product of the palm oil processing industry, namely palm kernel cake (PKC). Viewed from the production aspect, 60% of the total



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palm oil industry products are by-products. PKC is useful as an alternative feed ingredient for livestock because it has good nutritional composition and great potential as a source of concentrated feed ingredients for livestock (Arief *et al.*, 2019a).

In addition to dairy goats, livestock that can be developed as milk-producing is Etawa Crossbred Dairy Goats (ECDG). The ECDG crosses between Etawa goats and Indonesian Kacang goats. The advantage of ECDG is that they have good adaptability to the different environmental macroclimatic conditions in Indonesia. ECDG are dual-purpose type goats that have good reproductive characteristics and better nutritional milk content than cow's milk (Arief *et al.*, 2019b). ECDG is raised for milk production, especially in Indonesia (Arief *et al.*, 2019b). Goat's milk contains minerals such as Ca, P, and Mg which are higher than cow's and human milk. The high content of medium-chain fatty acids is beneficial for the body because it is rapidly oxidized by the liver and induces a full effect (Vaquil and Rathee, 2017). Besides, goat's milk has medicinal properties that can cure various diseases such as asthma and tuberculosis (Pal U *et al.*, 2011).

Research on the use of various forage sources combined with the provision of by-products from the palm oil industry and tofu waste as feed ingredients for lactating ECDG concentrates has never been carried out. If this potential is explored properly, non-conventional forage sources and the palm oil industry will play a significant role in providing animal feed, especially dairy goats, which are useful for supporting food self-sufficiency programs, especially milk in Indonesia (Pazla, 2018a).

This research aimed to study the productive traits and milk quality of ECDG fed on several sources of forage with palm kernel cake concentrate (PKCC).

## Materials and Methods

### *Ethical Approval*

This experiment has referred to research ethics using livestock based on the Republic of Indonesia government law number 18 of 2009 (Section 66), which addressed animal keeping, raising, killing, and proper treatment and care.

### *Experimental Design and duration*

This research was conducted at an ECDG livestock company in Payakumbuh, West Sumatra, Indonesia (-0.2330638,100.6268024). There were 16 ECDGs in the second month of lactation used in this research. Theselected ECDG at 1-1.5 years and 58-60 kg. All zoohygiene requirements are met in intensive goat farming (Hasan *et al.*, 2022)

This experiment used a 4 x 4 completely randomized design determined by four treatments of feed formulation as follows: A. 50% tofu waste (TW) + 50% Field grass (control); B. 25% TW + 25% Kernel Cake Concentrate (PKCC) + 50% tithonia; C. 25% TW+ 25% PKCC + 50% Cassava leaves; D.25% TW + 25% PKCC + 50% Gamal for a total of 16 experimental units. ECDGs were placed in individual cages with a size of 1.25 m x1.00 m. The experimental cage was given disinfectant (anti-microorganism) to inhibit and kill microorganism and all ECDG were given deworming before the study started. All ECDGs were confirmed not to have mastitis. The experiment was carried out for 50 days consisting of 30 days of the adaptation period, 15 days of the preliminary period, and 5 days of the collecting period.

**Table 1**. The nutritional content of each feed ingredient.

| Nutrient | Feedstuff | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (%) | Fields grass | T | CL | G | Rice bran | Tofu waste | PKC | Corn |
| Dry Matter | 23.29 | 25.57 | 31.10 | 21.42 | 87.80 | 28.40 | 91.83 | 85.80 |
| Organic Matter | 92.41 | 84.01 | 89.85 | 94.85 | 90.80 | 97.67 | 91.41 | 99.10 |
| Protein | 10.23 | 22.98 | 27.15 | 19.11 | 10.72 | 20.11 | 12,36 | 7.70 |
| Crude Fiber | 25.44 | 18.17 | 19.12 | 19.75 | 11.60 | 19.00 | 26.68 | 2.44 |
| Extract Ether | 3.64 | 04.71 | 3.52 | 2.98 | 08.73 | 01.25 | 8.23 | 3.50 |

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|---|---|---|---|---|---|---|---|---|
| NFE | 53.1 | 38.15 | 39.26 | 53.01 | 59.75 | 57.31 | 44.14 | 85.46 |
| NDF | 67.20 | 55.03 | 56.13 | 46.33 | 55.13 | 59.28 | 66.70 | 49.96 |
| TDN | 58.65 | 62.60 | 79.21 | 67.60 | 66.63 | 74.61 | 65.40 | 81.90 |

Note: T= Tithonia, CL = Cassava leaf, G=Gamal, PKC = Palm Kernel Cake, NFE = Nitrogen Free Extract, NDF =Neutral Detergent Fiber, TDN = Total Digestible Nutrient

**Table 2**. The composition and nutrients of palm kernel cake concentrate (%DM)

| Feed Ingredients | Level (%) |
|---|---|
| Palm kernel cake | 40.00 |
| Rice bran | 20.00 |
| Corn | 9.00 |
| Tofu waste | 30.00 |
| Mineral | 1.00 |
| **Nutrient** | **Percentage (%)** |
| Dry matter | 91.84 |
| Ash | 9.88 |
| Crude protein | 16.88 |
| Crude fiber | 13.22 |
| NFE | 55.06 |

| | |
|---|---|
| NDF | 62.84 |
| TDN | 66.36 |

Note: NFE = Nitrogen Free Extract, NDF =Neutral Detergent Fiber, TDN = Total Digestible Nutrient

**Table 3**. Composition of treatments ration (%)

| Feed Materials | Treatments | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Field grass | 50 | 0 | 0 | 0 |
| Tithonia | - | 50 | 0 | 0 |
| Cassava | - | - | 50 | 0 |
| Gamal | - | - | 0 | 50 |
| PKCC | - | 25 | 25 | 25 |
| Tofu waste | 50 | 25 | 25 | 25 |
| Total | 100 | 100 | 100 | 100 |
| Nutrient composition | | | | |
| Dry Matter | 25.85 | 42.85 | 45.61 | 40.77 |
| Ash | 4.96 | 11.05 | 8.13 | 5.63 |
| Protein | 15.17 | 20.74 | 22.82 | 18.80 |
| Crude Fiber | 14.48 | 17.14 | 18.02 | 17.93 |
| NFE | 55.21 | 47.17 | 47.72 | 54.60 |
| NDF | 63.24 | 58.05 | 58.60 | 53.70 |
| TDN | 66.63 | 66.54 | 74.85 | 69.04 |

Note: NFE = Nitrogen Free Extract, NDF =Neutral Detergent Fiber, TDN = Total Digestible Nutrient

The experimental ration consisted of forage and concentrate in a ratio of 50:50. The ration was given at 3.5% of body weight-based dry matter (NRC, 2007). Drinking water was available *ad libitum*. The nutritional contents of each feed ingredient are presented in Table 1. The composition and nutritional contents of palm kernel cake-based concentrates are presented in Table 2. The composition and nutritional contents of the experimental rations are explained in Table 3. Proximate analysis of feed ingredients (dry matter, ash, protein, extract ether, and crude fiber) was carried out following (AOAC, 2005). NDF was determined following (Goering and Van Soest, 1970). TDN was estimated with the following formula (Moran, 2005):

$$TDN = 5.31 + 0.412\ CP\% + 0.249\ CF\% + 1.444\ EE\% + 0.937\ NFE\%$$

Where: CP = crude protein; CF = crude fiber; EE = extract ether; NFE = nitrogen free extract

## *Collection of Fecal Samples*

The sewage collection from the ECDG was carried out for 5 days from the $46^{th}$ day to the $50^{th}$ day. The dirt was weighed every day at 8 am (the weight of fresh dirt).Then 200 grams of dirt was taken as a sample to analyze the dry matter, ash, and crude protein content. The samples were oven to 60°C for 8 hours and then weighed (dry weight). Before analysis in the laboratory, goat hair attached to the manure was removed.

## *Milk Sample Collection*

Every day, the milk production of each experimental animal was weighed and recorded. Milk samples were taken 2 times during the study for quality testing asmuch as 300 mL per treatment goat. Before sampling,the nipples were cleaned so that the dirt that sticks out can be lost and does not contaminate the milk. Then,milk sample was taken and stored in a cool box to avoid microbial contamination. Finally, milk samples were taken to the laboratory for analysis.

## *Parameters Measured*

The variables measured were dry matter intake (DMI), organic matter intake (OMI), crude protein intake (CPI), dry matter digestibility (DMD), organic matter digestibility (OMD), Crude protein digestibility (CPD), milk production, and milk quality parameters such as

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milk protein, lactose, milk fat, total solid (TS), Solid Non-Fat (SNF), pH, BJ, and Ca and P mineral. Digestibility measurement in vivo using the total collection method (Jamarun *et al*., 2021): weighing the entire ration eaten and Weighing all excreted feces. Then Analyze the nutritional content of rations and feces. Protein, lactose, and fat were measured using the methodof (AOAC, 2005), SNF and TS were measured using lactoscan MCC50, pH was measured using a pH meter digital HI9807-phep, Singapura, while Specific Grafity was measured using a Lactodensimeter merk Funke Gerber Germany.

### *Statistical Analysis*

Experimental data were analyzed using the analysisof variance (ANOVA) with a completely randomizeddesign (Steel and Torrie, 2002) using SPSS software version 20. Parameters mean showed statistical differences in probabilities level of $P<0.05$ compared using the Duncan multiple range tests. The statistical model and experimental design were as foloows:

$$Y\mathrm{ij} = \mu + M\mathrm{i} + \mathrm{sij}$$

Where**,** *Yij* denotes the observation variable, $\mu$ denotes the overall mean, *M* denotes the effect of treatments and $\varepsilon ij$ denotes the residual effect.

## Results

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## *Milk Production*

Optimal milk production and quality are the goal and hope of dairy goat farmers. The quality of feed greatly determines the optimal production and quality of milk. Milk production in this study did not differ between treatments (P>0.05), but treatments that received various types of forage (Tithonia, Cassava leaves, and Gamal) and PKCC showed higher milk production (Fig. 1). Relationship between crude protein intake and milk production (Fig.2)

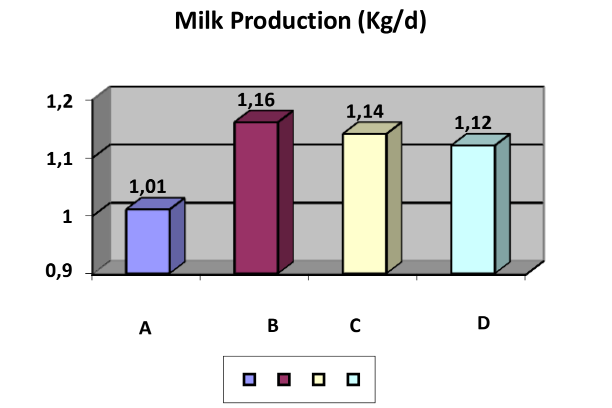


Fig.1: Milk production as affected by treatments

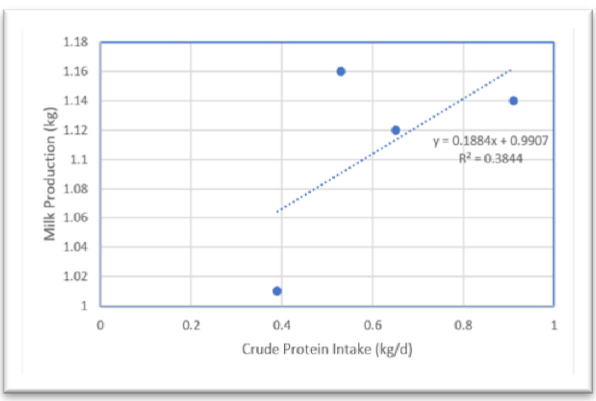


Fig.2 Relationship between crude protein intake and milk production

## *Milk Quality*

The results on the quality of ECDG goat milk showed that treatment C had the highest milk protein contents (Table 4) which was not significantly different from treatments B and D. Treatment B resulted in higher levels of lactose (P<0.05). The highest milk fat content was found in treatment B which was not significantly different from treatment D. The highest SNF was obtained due to the high protein and lactose contents in specific gravity of milk. Treatment B had the highest total solid, 21.78%, and treatment A exhibited the lowest total solid up to 16.87%. The pH value of milk in this study was 6.76-6.86. The contents of Ca and P in treatment A expose the lowest value when compared to treatments B, C, and D, which received ingredients from Tithonia forage, Cassava leaves, and Gamal, as well as PKCC.

This study's linear regression equation between crude protein intake and milk production obtained the formula: $y = 0.18884x+0.9907$. The equation shows the results of the correlation value (r) 0.62 and the coefficient of determination ($R^2$) 0.3844, which indicates that milk production, as much as 38.44%, is influenced by crude protein intake and 61.56% is influenced by other factors.

**Table 4**. Milk quality of the different experimental groups.

| Parameters | Treatments | | | | SEM |
|---|---|---|---|---|---|
| | A | B | C | D | |
| Protein (%) | 4.89$^a$ | 5.99$^b$ | 6.26$^b$ | 6.01$^b$ | 0.25 |
| Lactose (%) | 5.58$^a$ | 6.73$^a$ | 3.55$^b$ | 3.44$^b$ | 0.54 |
| Fat (%) | 3.58$^a$ | 6.78$^b$ | 3.70$^a$ | 6.05$^b$ | 0.34 |
| Solid Non-Fat (SNF) (%) | 13.30 | 15.01 | 13.92 | 13.79 | 0.60 |
| Total Solid (TS) (%) | 16.87$^a$ | 21.78$^c$ | 17.62$^{ab}$ | 19.84$^{bc}$ | 0.81 |
| pH | 6.86 | 6.78 | 6.76 | 6.81 | 0.04 |
| Specific Gravity (g/cm$^3$) | 1.0285 | 1.0289 | 1.0288 | 1.0288 | 0.0002 |
| Ca (%) | 0.34$^a$ | 0.47$^b$ | 0.56$^c$ | 0.73$^d$ | 0.18 |
| P (%) | 0.23 | 0.27 | 0.29 | 0.26 | 0.24 |

Note: Different superscripts (a,b,c,d) in the same line showed significant differences (P>0.05)

## *Feed Intake*

The replacement of field grass with various forages (Tithonia, Cassava leaves, and Gamal) and the replacement of tofu waste with PKCC could increase (P<0.05) the dry matter intake (DMI) (Table 5). Treatments B, C, and D revealed better DMI. The average organic matter intake (OMI) during the study ranged from 2.23-3.53 Kg/e/h. The OMI in treatment A was significantly (P<0.05) lower than the other treatments. Crude protein intake (CPI) in treatments B, C, and D indicated a higher value (P < 0.05). Treatment C exhibited the highest value (0.91 kg/head/day).

**Table 5.** Feed intake of the different experimental groups.

| Parameters | Treatments | | | | SEM |
|---|---|---|---|---|---|
| (Kg/day) | A | B | C | D | |
| DMI | 2.37$^a$ | 3.06$^b$ | 3.85$^c$ | 3.31$^d$ | 0.63 |
| OMI | 2.23$^a$ | 2.81$^b$ | 3.53$^c$ | 3.12$^d$ | 0.64 |
| CPI | 0.39$^a$ | 0.53$^{ab}$ | 0.91$^c$ | 0.65$^b$ | 0.64 |

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treatment B. The statistical analysis showed that there was no significant difference between treatments on the

Note: Different superscripts (a.b,c,d) in the same line showed significant differences (P>0.05)

### *Nutrient Digestibility*

The treatment of various forage sources and PKCC concentrates gave a significantly different effect (P<0.05) on the digestibility of dry matter, organic matter, and crude protein (Table 6). Treatment C revealed the highest dry matter digestibility (DMD) (76.85%) and organic matter digestibility (OMD) (77.25%) while the lowest was treatment A (69.43%). The range of crude protein digestibility (CPD) of the treatment was 71.26-86.01%. Also, treatment C showed the highest CPD (88.01%) while, treatment A appeared to have the lowest CPD (71.26%).

**Table 6**. Nutrient digestibility of the different experimental groups.

| Parameters (%) | Treatments A | B | C | D | SEM |
|---|---|---|---|---|---|
| Dry Matter Digestibility | 67.97ᵃ | 73.35ᵇ | 76.85ᶜ | 68.45ᵃ | 0.62 |
| Organic Matter Digestibility | 69.43ᵃ | 74.07ᵇ | 77.25ᶜ | 69.97ᵃ | 0.60 |
| Crude Protein Digestibility | 72.19ᵃ | 74.83ᵃ | 86.01ᵇ | 71.26ᵃ | 2.10 |

Note: Different superscripts (a,b,c,d) in the same line showed significant differences (P<0.05)

## Discussion

### *Milk Production*

Milk production in this study did not differ between treatments, but treatments that received various types of forage and PKCC+TW (B, C, and D) revealed higher milk production. Milk production is related to the protein value of the ration. Rations B, C, and D contained higher crude protein. In the rumen, crude protein will be converted into $NH_3$. Rumen microbes utilized nitrogen from $NH_3$ for growth (Pazla *et al.,* 2021b). Optimal microbial growth increased microbial activity in fermenting polysaccharides and converted them into VFA (Suyitman *et al.,* 2021). VFA is the primary source of energy in ruminants. Optimal energy will optimize livestock productivity in milk production.

Although not statistically significant, milk production increased by replacing field grass with Tithonia, Gamal, and Cassava leave. This proves that Tithonia leaves, Cassava leaves, Gamal, and concentrate (PKCC+TW) could increase ECDG milk production. The higher milk production in treatments B, C, and D was in line with the crude protein content of the ration contributed from Tithonia, Cassava leaves, and Gamal, as well as PKCC+TW. Protein plays a significant role in maintaining mammary gland cells. The production of hormones and enzymes for milk biosynthesis is also strongly influenced by feed protein. Arief *et al.* (2018a) reported ECDG milk production of about 1.83 Kg/day which is different from the current study. The difference is due to the type of forage and concentrates used.

### *Milk Quality*

The value of milk protein in this study ranged from 4.89-6.26% and this value is higher than the normal range of 2.75-3% (SNI, 2011). Based on the Thai Agricultural Standard, this milk protein has been categorized as premium milk quality (TAS 6006, 2008). Treatments B and C with Tithonia forage, Cassava leaves, and PKCC+TW showed the highest milk protein. The increase in milk protein contents was caused by the combination of forages containing high protein (Tithonia and Cassava leaves) with PKCC+TW. Rations B and C can increase the supply of amino acids in the rumen to the intestine. Consumption of high-quality ration protein by ECDG is not all degraded in the rumen. Protein also enters the small intestine to be converted into amino acids. Amino acids are absorbed in the small intestine, flow through the circulatory system, and get into the

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udder. After that, the process continued with the synthesis of milk protein. The results of this study followJamarun *et al.* (2020a), who stated that dairy goats given high crude protein could increase milk protein.

Glucose and galactose are the constituent elements of lactose while the average lactose content in this study is about 3.44-6.73%. According to (SNI, 2011) the lactose content of milk is 2-3%. Ratya *et al.* (2017) reported that the lactose content of ECDG milk was 3.70-3.80. This study indicated that the lactose content of ECDG milk is still in the normal category, and some have the premium category. Treatment B (Tithonia + PKCC+TW) resulted in higher levels of lactose. Tithonia contains amino acids.The absorbed amino acids in the intestine were broken down into simple sugars. Gluconeogenesis in the liver will increase the glucose level in the blood so that the milk lactose level also rises. Zhang *et al.* (2018) stated that glucose is the main precursor in the formation of lactose in milk. High-soluble carbohydrates cause the substrate availability needed in the milk lactose synthesis process (Arief *et al.*, 2018b). Lactose in treatment B was not different from treatment A. Treatment A contained more concentrate (tofu waste). Tofu waste is feed ingredients classified as carbohydrates that are easily digested. Carbohydrates are converted to VFA (propionic acid). Propionic acid enters the process of gluconeogenesis. The blood immobilizes glucose in the udder gland to synthesize lactose in milk (Arief *et al.,* 2020).

The highest milk fat content was found in treatment B (Tithonia + PKCC + TW) and was not significantly different from treatment D (Gamal + PKCC +TW). Treatments A and C were also not critically different in the fat contents. The high-fat contents in treatment B were due to the consumption of crude fiber in the ration, which was higher than the other treatments. In addition, the increased milk fat contents are also influenced by high feed fat consumption. The fat in the rumen is converted into fatty acids (Makmur *et al.,* 2020). Fatty acids are the precursors in milk fat formation. ECDGs that consume feed with high-fat content tend to have high milk fat.

The SNF value of the ECDG treatment is about 13.30-15.01%. The lowest mean value was in the control treatment (A. The highest mean value was indicated by treatment B and followed by treatments C and D. These data indicated that the SNF of treated ECDG milk exceeded the standard. SNI (2011) stated that the SNF requirement for milk is 6-8%. The highest SNF was obtained due to the high protein and lactose content in treatment B. The rise of SNF level occurs due to the fat content that is not included in that section so the remaining protein and lactose levels can affect the high percentage produced. The high SNF in treatment B was also influenced by the high BJ value in the treatment compared to other treatments. Utari *et al.* (2012)reported that the SNF of goat milk-fed with a complete diet ranged from 10.33-11.61%. The difference is due to the high disparity between the dry matter and milk fat content.

Specific gravity is a derived quantity from the quotient of mass and volume. The specific gravity ofmilk can be used to determine the adulteration of milk added by coconut milk, and other ingredients that shouldnot be present in whole milk (Fitriansyah *et al.,* 2014). This study indicated that the average specific gravity of ECDG milk treatment with the highest average was obtained in treatment B, while the lowest average specific gravity was obtained in treatment A. The statistical analysis results showed that there was no significant between treatments on the milk-specific gravity. The specific gravity of milk was in the normal range, according to (SNI, 2011). Bhattarai (2012) stated that the specific gravity of goat's milk is higher than cow's milk. Changes in specific gravity are influenced bythe specific gravity of each component of milk consisting of protein, lactose, and fat.

Total solid is a description of the solid content in milk. Treatment B has the highest total solid, while treatment A shows the lowest total solid. The provisionof various types of forage and PKCC+TW on ECDG canproduce a total solid that is following (SNI, 2011) which is a minimum of 10.8%. The administration of various forage and PKCC+TW was significantly different ($P<0.05$) from the total solid.

The low total solid in treatment A was due to the lower nutritional quality in the treatment than other treatments. Treatment A only contained field grass and tofu waste. The difference between the total solid components between treatments occurred due to differences in the use of nutrients in the feed. Similarly, Arief *et al.,* (2021) stated that the total solid depends on the nutrients consumed by livestock. Nutrients will be used as precursors in the formation of solids in milk.

The pH value of milk in this study was 6.76-6.86. The value follows the standard of (TAS 6006, 2008) which is 6.5-6.8. The PH value is an indication of damage to milk. Different pH values can be caused by the content of freshly milked fresh milk such as $CO_2$, phosphate, citrate, and protein. Some of these compounds affect the ability of milk buffer. Milk buffer can inhibit milk's deterioration, which is induced by changes in the pH and acidity of milk (Zain, 2013). If there is bacterial activity, the pH value changes to acid (Swadayana *et al.,* 2012). A pH value above 6.7 usually indicates the possibility of mastitis (Legowo *et al.,* 2009).

The content of Ca and P in treatment A which only received feed ingredients from field grass and tofu waste was the lowest value. The nutritional quality of the given ration determines the minerals of the milk produced. Pazla *et al.,* (2021c) reported that the Ca and P content of Tithonia was richer than field grass, namely 0.99% Ca and 0.33% P, while field grass only contained 0.07% Ca and 0.09% P.

## *Feed Intake*

The replacement of field grass with various forages (Tithonia, Cassava leaves, and Gamal) and the replacement of tofu waste with PKCC can increase the dry matter intake (DMI). Treatments B, C, and D showed better DMI. Pazla *et al.,* (2018b) stated that high DMI indicated good palatability of feed ingredients. Good palatability encourages livestock to consume many nutrients. The performance of an animal will be more productive due to nutrition. Palatability is the most influential factor in the DMI of livestock. The DMI in this study showed a better percentage when compared to Isah *et al.,* (2015) with DMI values of 0.89 kg/head/day. Rosartio *et al.,* (2015) get a DMI that is almost the same as this study, which is 2.73-3.83 kg/head/day. The difference is due to the quality of the forage provided.

The highest DMI was found in treatment C with an average of 3.85 kg/head/day. Giving Cassava leaves up to 50% is still palatable for ECDG so their consumption increases. This is due to the goat's habit of "browsing" in search of food and its preference for leaves. The highest crude protein level in treatment C was also the factor causing the increase in DMI. Similarly, Suyitman *et al.*, (2020) state that the DMI of feed is influenced by feed digestibility, palatability, crude protein contents, and organic matter contents.

Treatment A showed the lowest DMI. The low intake in treatment A was caused by the forage given. Field grass has low nutrient contents and palatability compared to forages in other treatments.

The intake pattern of organic matter follows the pattern of DMI. Dry matter is the main component in addition to water content in animal feed ingredients, while organic matter is part of dry matter. The increasein DMI impacted the rise of OMI as reported by (Febrina*et al.*, 2017). The average OMI during the study ranged from 2.23-3.53 Kg/e/h. The OMI in treatment A was significantly lower than in the other treatments. LowOMC is caused by low DMI.

Crude protein intake in treatments B, C, and D showed a higher value. Treatment C which got Cassava leaf forage revealed the highest value (0.91 kg/head/day). The crude protein content of Cassava leaves is also higher than other forages. CPI is strongly influenced by the crude protein content of feed ingredients. In addition, DMI was also the factor causing the rise of CPI in treatment C. Likewise, Arief *et al.* (2021b) stated that the CPI was influenced by the protein content in the ration. The high CPI will affect the high utilization of feed protein for production needs. Giving Cassava leaves can increase the CPI.

Marwah *et al.*, (2010) found a lower CPI than the CPI in this study, which was 0.34 kg/head/day. The difference is due to the distinct types of forage and concentrates given to ECDG. The ration in a recent study was superior because the forage provided had high protein and concentrate with more diverse components.

The anti-nutritional effect of Tithonia, Cassava, and Gamal leaves up to 50% in the ration has not been seen in reducing feed intake. This proves that up to a level of 50%, the provision of Tithonia, Cassava, and Gamal in rations is safe for livestock. Several studies on Tithonia, Cassava, and Gamal added to the ration mix did notaffect the productivity and digestibility of ruminants if the dose was not excessive (Jamarun *et al.*, 2020b).

*Nutrient Digestibility*

The treatment of various forage sources and PKCC+TW concentrates gave a significantly different effect on the digestibility of dry matter, organic matter, and crude protein. ECDG that received Cassava leaf forage and PKC concentrate revealed higher digestibility than the goats that were given field grass, Tithonia, and Gamal. This means that cassava leaves can play a role in increasing digestibility.

Whether or not the quality of a ration given to livestock can be seen from the percentage of DMD. The higher the DMD, the higher the opportunity for nutrients utilized by livestock for growth and production. Odedire dan Oloidi (2014) obtained lower DMD scores than this study, which was 70.98%. Isah *et al.*, (2015) got the higher DMD which was 754%. The difference in DMD is due to the type and nutritional content of the rations given.

The average DMD value of the treatment ration increased with the provision of tithonia forage, Cassava leaves, and PKC concentrate. In this case, this is due to the better nutritional content of the ration. The percentage of OMD in this study ranged from 69.43 to 77.25%. The treatment of various forages and PKC- based concentrates had a significant effect on OMD. Treatment C got the highest OMD (77.25%) while the lowest was treatment A (69.43%). The OMD value increased along with the rise of the DMD. Jamarun *et al.* (2018c) reported that the pattern of OMD is related to DMD. Most of the dry matter content is digestible organic matter such as carbohydrates, proteins, and fats.

The range of crude protein digestibility of the treatment was 71.26-86.01%. Treatment C got the highest CPD (88.01%) while treatment A got the lowest CPD (71.26%). The chemical composition of feed ingredients dramatically affects the level of digestibility. The quality of the ration is proportional to the digestibility of crude protein. CPD is also associated with the consumption of crude protein. High crude protein consumption will result in high crude proteindigestibility. Putri *et al.* (2021) stated that crude protein digestibility is influenced by microbial protein synthesis. Microbial protein synthesis will increase along with the rise in ration protein (Pazla *et al.*, 2018c).

The treatment of giving various forages and PKC+TW concentrates had a significant effect on the increase in CPD. This means that the application of Tithonia, Cassava, and Gamal up to 50% could maintain the CPD. Crude protein digestibility is highly dependent on the performance of proteolytic bacteria. Proteolytic bacteria are bacteria that produce extracellular protease enzymes that will break down protein in feed. The significant difference between treatments was due to different proportions of proteolytic bacteria in each treatment. The CPD in this study was higher than Supriyati and Haryanto (2011), who obtained a CPD of the combination of elephant grass and palm kernel cake of 73.027% - 75.99%. The difference is due to the feed ingredients which are concentrate and forage.

## Conclusion

Replacement of field grass with various forage sources and replacement of tofu waste with concentrate-based palm kernel cake could increase feed consumption and digestibility, as well as increases protein, lactose, fat, and calcium of milk.

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## Author Contribution

**Arief:** Designed the research plan, and organized and supervised the study.

**Roni Pazla:** Conducted the research, analyzed data, and contributed to the writing of the manuscript.

## Conflict of Interest

The authors declare that they have no conflict of interest.

## Ethics

This article is original and has never been published before. The author has also confirmed to all authors involved in this study to read and agree to the contents of this article and that there are no ethical issues involved.

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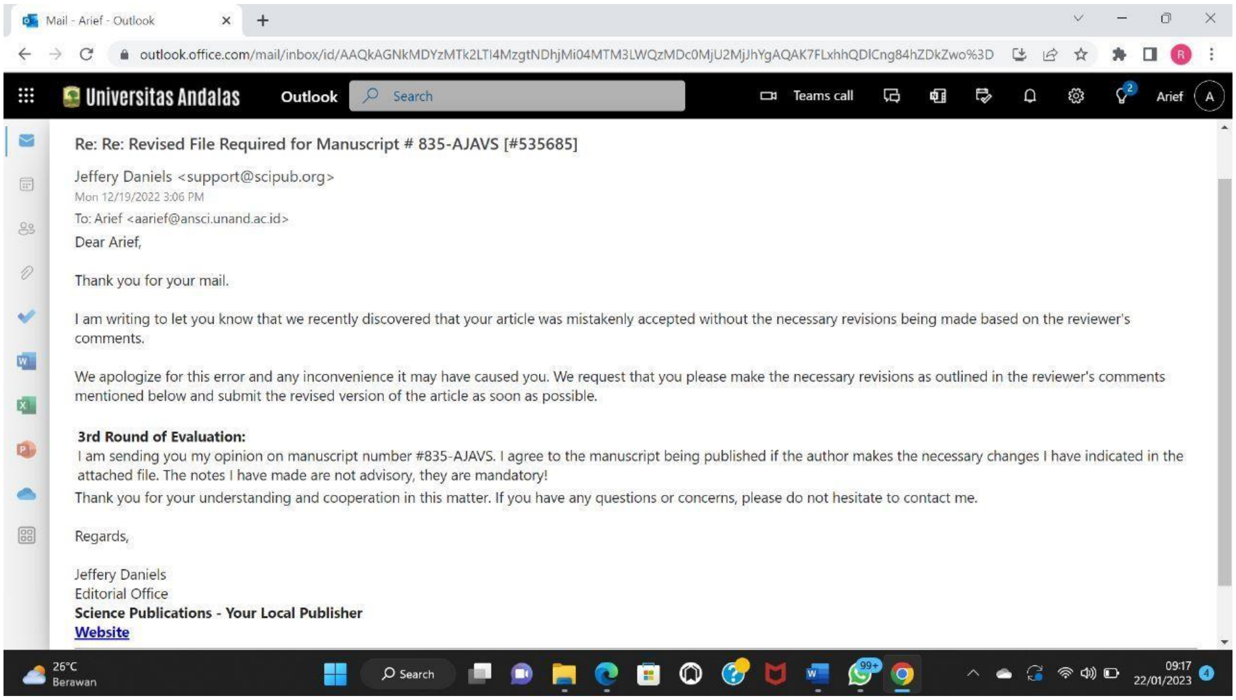

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Original Research Paper

# Milk Production and Quality of Etawa Crossbred Goats with Non-Conventional Forages and Palm Concentrates

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**Abstract -** Using Tithonia (*Tithonia diversifolia*), Cassava leaves (*Manihot utilisima*), and Gamal (*Gliricidia sepium*) as an alternative fiber and palm concentrate as an alternative protein is one of the ways to do this effective feeding strategy under a limited supply or lack of feed sources for Etawa Crossbreed Dairy Goats (ECDG)**.**This research aimed to study the productive traits and milk quality of ECDG fed on several sources of forage with palm kernel cake concentrate (PKCC). The experimental design was completely randomized with four treatments of feed formulation. Treatment formulations were as follows: A. 50% tofu waste (TW) + 50% field grass (control); B. 25% TW + 25% PKCC + 50% tithonia (*Tithonia diversifolia*); C. 25% TW+ 25% PKCC + 50% cassava leaves (*Manihot utilisima*); D. 25% TW + 25% PKCC + 50% Gamal (*Gliricidia sepium*). The results showed were significant (P<0.05) on parameters such as DMI, OMI, CPI, DMD, OMD, CPD, protein, lactose, fat, TS, and Ca of milk. It can be concluded that the replacement of field grass with forage sources such as Tithonia, Cassava leaves, and Gamal and the replacement of tofu waste with concentrate-based palm kernel cake could increase feed intake, digestibility, protein, lactose, and fat of milk.

**Keywords:** Goat, Forage, Milk, Nutrition, Palm concentrate.

## Introduction

Forage such as elephant grass is the main feed for ruminants to provide crude fiber. Other unconventional forage sources are Tithonia (*Tithonia diversifolia*), Cassava leaves (*Manihot utilisima*), and Gamal (*Gliricidia sepium*) were suggested. Tithonia is a shrub or weed-like plant that grows a lot in an empty land, roadsides, and rice fields. In West Sumatra, tithonia is also known as the paitan plant because of its bitter leaves(Pazla *et al.,* 2021a). Tithonia plants have not been widely used as a source of organic matter, fertilizer, or animal feed ingredients. However, tithonia is quite favored by livestock because of its high protein content of up to 22.98% (Jamarun *et al.*, 2019). Also, Cassava leaves and Gamal are nutritious foraged ingredients that are useful for livestock.

Furthermore, livestock needs concentrated feed ingredients for energy. The prices of concentrate ingredients, especially corn, are expensive. Therefore, it is necessary to look for alternative feed ingredients with abundant availability and quality to reduce dependence on imported feed ingredients. One of the concentratefeed ingredients is a by-product of the palm oil processing industry, namely palm kernel cake (PKC). Viewed from the production aspect, 60% of the total palm oil industry products are by-products. PKC is useful as an alternative feed ingredient for livestock



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because it has good nutritional composition and great potential as a source of concentrated feed ingredients for livestock (Arief *et al.*, 2019a).

In addition to dairy goats, livestock that can be developed as milk-producing is Etawa Crossbred Dairy Goats (ECDG). The ECDG crosses between Etawa goats and Indonesian Kacang goats. The advantage of ECDG is that they have good adaptability to the different environmental macroclimatic conditions in Indonesia. ECDG are dual-purpose type goats that have good reproductive characteristics and better nutritional milk content than cow's milk (Arief *et al.*, 2019b). ECDG is raised for milk production, especially in Indonesia (Arief *et al.*, 2019b). Goat's milk contains minerals such as Ca, P, and Mg which are higher than cow's and human milk. The high content of medium-chain fatty acids is beneficial for the body because it is rapidly oxidized by the liver and induces a full effect (Vaquil and Rathee, 2017). Besides, goat's milk has medicinal properties that can cure various diseases such as asthma and tuberculosis (Pal U *et al.*, 2011).

Research on the use of various forage sources combined with the provision of by-products from the palm oil industry and tofu waste as feed ingredients for lactating ECDG concentrates has never been carried out. If this potential is explored properly, non-conventional forage sources and the palm oil industry will play a significant role in providing animal feed, especially dairy goats, which are useful for supporting food self-sufficiency programs, especially milk in Indonesia (Pazla, 2018a).

This research aimed to study the productive traits and milk quality of ECDG fed on several sources of forage with palm kernel cake concentrate (PKCC).

## Materials and Methods

### *Ethical Approval*

This experiment has referred to research ethics using livestock based on the Republic of Indonesia government law number 18 of 2009 (Section 66), which addressed animal keeping, raising, killing, and propertreatment and care.

### *Experimental Design and duration*

This research was conducted at an ECDG livestock company in Payakumbuh, West Sumatra, Indonesia (-0.2330638,100.6268024). There were 16 ECDGs in the second month of lactation used in this research. The selected ECDG at 1-1.5 years and 58-60 kg. All zoohygiene requirements are met in intensive goat farming (Hasan *et al.*, 2022)

This experiment used a 4 x 4 completely randomized design determined by four treatments of feed formulation as follows: A. 50% tofu waste (TW) + 50% Field grass (control); B. 25% TW + 25% Kernel Cake Concentrate (PKCC) + 50% tithonia; C. 25% TW+ 25% PKCC + 50% Cassava leaves; D.25% TW + 25% PKCC + 50% Gamal for a total of 16 experimental units. ECDGs were placed in individual cages with a size of 1.25 m x1.00 m. The experimental cage was given disinfectant (anti-microorganism) to inhibit and kill microorganisms and all ECDG were given deworming before the study started. All ECDGs were confirmed not to have mastitis. The experiment was carried out for 50 days consisting of 30 days of the adaptation period, 15 days of the preliminary period, and 5 days of the collecting period.

**Table 1**. The nutritional content of each feed ingredient.

| Nutrient (%) | Feedstuff | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Fields grass | T | CL | G | Rice bran | Tofu waste | PKC | Corn |
| Dry Matter | 23.29 | 25.57 | 31.10 | 21.42 | 87.80 | 28.40 | 91.83 | 85.80 |
| Organic Matter | 92.41 | 84.01 | 89.85 | 94.85 | 90.80 | 97.67 | 91.41 | 99.10 |
| Protein | 10.23 | 22.98 | 27.15 | 19.11 | 10.72 | 20.11 | 12,36 | 7.70 |
| Crude Fiber | 25.44 | 18.17 | 19.12 | 19.75 | 11.60 | 19.00 | 26.68 | 2.44 |
| Extract Ether | 3.64 | 04.71 | 3.52 | 2.98 | 08.73 | 01.25 | 8.23 | 3.50 |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NFE | 53.1 | 38.15 | 39.26 | 53.01 | 59.75 | 57.31 | 44.14 | 85.46 |
| NDF | 67.20 | 55.03 | 56.13 | 46.33 | 55.13 | 59.28 | 66.70 | 49.96 |
| TDN | 58.65 | 62.60 | 79.21 | 67.60 | 66.63 | 74.61 | 65.40 | 81.90 |

Note: T= Tithonia, CL = Cassava leaf, G=Gamal, PKC = Palm Kernel Cake, NFE = Nitrogen Free Extract, NDF =Neutral Detergent Fiber, TDN = Total Digestible Nutrient

**Table 2**. The composition and nutrients of palm kernel cake concentrate (%DM)

| Feed Ingredients | Level (%) |
|---|---|
| Palm kernel cake | 40.00 |
| Rice bran | 20.00 |
| Corn | 9.00 |
| Tofu waste | 30.00 |
| Ultra Mineral | 1.00 |
| Nutrient | Percentage (%) |
| Dry matter | 91.84 |
| Ash | 9.88 |
| Crude protein | 16.88 |
| Crude fiber | 13.22 |
| NFE | 55.06 |
| NDF | 62.84 |
| TDN | 66.36 |

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Note: NFE = Nitrogen Free Extract, NDF =Neutral Detergent Fiber, TDN = Total Digestible Nutrient

**Table 3**. Composition of treatments ration (%)

| Feed Materials | Treatments | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Field grass | 50 | 0 | 0 | 0 |
| Tithonia | - | 50 | 0 | 0 |
| Cassava | - | - | 50 | 0 |
| Gamal | - | - | 0 | 50 |
| PKCC | - | 25 | 25 | 25 |
| Tofu waste | 50 | 25 | 25 | 25 |
| Total | 100 | 100 | 100 | 100 |

The experimental ration consisted of forage and concentrate in a ratio of 50:50. The ration was given at 3.5% of body weight-based dry matter (NRC, 2007). Drinking water was available *ad libitum*. The nutritional contents of each feed ingredient are presented in Table 1. The composition and nutritional contents of palm kernel cake-based concentrates are presented in Table 2. The composition and nutritional contents of the experimental rations are explained in Table 3. Proximate analysis of feed ingredients (dry matter, ash, protein, extract ether, and crude fiber) was carried out following (AOAC, 2005). NDF was determined following (Goering and Van Soest, 1970). TDN was estimated with the following formula (Moran, 2005):

$$TDN = 5.31 + 0.412\ CP\% + 0.249\ CF\% + 1.444\ EE\% + 0.937\ NFE\%$$

Where: CP = crude protein; CF = crude fiber; EE = extract ether; NFE = nitrogen free extract

### *Collection of Fecal Samples*

The sewage collection (n=16) from the ECDG was carried out for 5 days from the 46$^{th}$ day to the 50$^{th}$ day. The dirt was weighed every day at 8 am (the weight of fresh dirt). Then 200 grams of dirt was taken as a sample to analyze the dry matter, ash, and crude protein content. The samples were oven to 60°C for 8 hours and then weighed (dry weight). Before analysis in the laboratory, goat hair attached to the manure was removed.

### *Milk Sample Collection*

Every day, the milk production of each experimental animal was weighed and recorded. Milk samples (n=16) were taken 2 times during the study for quality testing as much as 300 mL per treatment goat. Before sampling, the nipples were cleaned so that the dirt that sticks out can be lost and does not contaminate the milk. Then,milk sample was taken and stored in a cool box to avoid microbial contamination.

### *Parameters Measured*

The variables measured were dry matter intake (DMI), organic matter intake (OMI), crude protein intake(CPI), dry matter digestibility (DMD), organic matter digestibility (OMD), Crude protein digestibility (CPD), milk production, and milk quality parameters such as milk protein, lactose, milk fat, total solid (TS), Solid Non-Fat (SNF), pH, BJ, and Ca and P mineral. Digestibility measurement in vivo using the total collection method (Jamarun *et al.*, 2021): weighing the entire ration eaten and Weighing all excreted feces.

Protein, lactose, and fat were measured using the method of (AOAC, 2005), SNF and TS were measured using lactoscan MCC50, pH was measured using a pH meter digital HI9807-phep, Singapura, while Specific Grafity was measured using a Lactodensimeter merk Funke Gerber Germany.

### *Statistical Analysis*

Experimental data were analyzed using the analysis of variance (ANOVA) with a completely randomized design (Steel and Torrie, 2002) using SPSS software version 20. Parameters mean showed statistical differences in probabilities level of $P<0.05$ compared using the Duncan multiple range tests. The statistical model and experimental design were as follows:

$$Y\mathrm{ij} = \mu + M\mathrm{i} + \mathrm{sij}$$

Where**,** $Yij$ denotes the observation variable, $\mu$ denotes the overall mean, $M$ denotes the effect of treatments and $\varepsilon ij$ denotes the residual effect.

## Results

### *Milk Production*

The quality of feed greatly determines the optimal production and quality of milk. Milk production in this study did not differ between treatments, but treatments that received various types of forage (Tithonia, Cassava leaves, and Gamal) and PKCC showed higher milk production (Fig. 1) and no relationship between. crude protein intake and milk production (Fig.2)

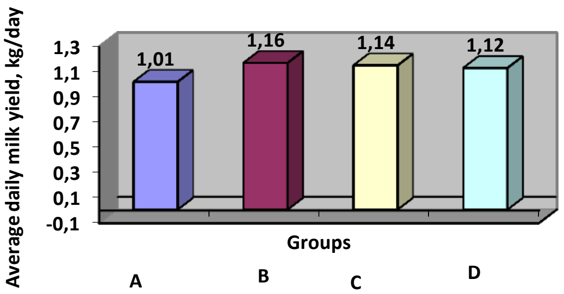


Fig.1: Milk production as affected by treatments, kg/d

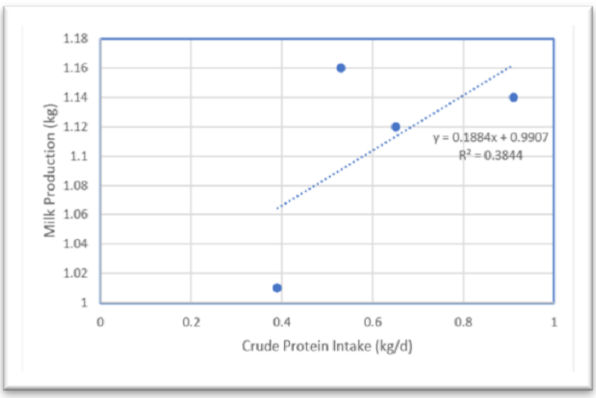


Fig.2 Relationship between crude protein intake and milk production

## *Milk Quality*

The results on the quality of ECDG goat milk showed that treatment C had the highest milk protein contents (Table 4) which was not significantly different from treatments B and D. Treatment B resulted in higher levels of lactose (P<0.05). The highest milk fat content was found in treatment B which was not significantly different from treatment D. The highest SNF was obtained due to the high protein and lactose contents in treatment B. The statistical analysis showed that there was no significant difference between treatments on the specific gravity of milk. Treatment B had the highest total solid, 21.78%, and treatment A exhibited the lowesttotal solid up to 16.87%. The pH value of milk in this study was 6.76-6.86. The contents of Ca and P in treatment A expose the lowest value when compared to treatments B, C, and D, which received ingredients from Tithonia forage, Cassava leaves, and Gamal, as well as PKCC.

**Table 4**. Milk quality of the different experimental groups.

| Parameters | Treatments | | | SEM | A |
|---|---|---|---|---|---|
| | | B | C | D | |
| Protein (%) | 4.89$^a$ | 5.99$^b$ | 6.26$^b$ | 6.01$^b$ | 0.25 |
| Lactose (%) | 5.58$^a$ | 6.73$^a$ | 3.55$^b$ | 3.44$^b$ | 0.54 |
| Fat (%) | 3.58$^a$ | 6.78$^b$ | 3.70$^a$ | 6.05$^b$ | 0.34 |
| Solid Non-Fat (SNF) (%) | 13.30 | 15.01 | 13.92 | 13.79 | 0.60 |
| Total Solid (TS) (%) | 16.87$^a$ | 21.78$^c$ | 17.62$^{ab}$ | 19.84$^{bc}$ | 0.81 |
| pH | 6.86 | 6.78 | 6.76 | 6.81 | 0.04 |
| Specific Gravity (g/cm$^3$) | 1.0285 | 1.0289 | 1.0288 | 1.0288 | 0.0002 |
| Ca (%) | 0.34$^a$ | 0.47$^b$ | 0.56$^c$ | 0.73$^d$ | 0.18 |
| P (%) | 0.23 | 0.27 | 0.29 | 0.26 | 0.24 |

Note: Different superscripts (a,b,c,d) in the same line showed significant differences (P<0.05)

## *Feed Intake*

The replacement of field grass with various forages (Tithonia, Cassava leaves, and Gamal) and the replacement of tofu waste with PKCC could increase (P<0.05) the dry matter intake (DMI) (Table 5). Treatments B, C, and D revealed better DMI. The average organic matter intake (OMI) during the study ranged from 2.23-3.53 Kg/e/h. The OMI in treatment A was significantly (P<0.05) lower than the other treatments. Crude protein intake (CPI) in treatments B, C, and D indicated a higher value (P < 0.05). Treatment C exhibited the highest value (0.91 kg/head/day).

**Table 5.** Feed intake of the different experimental groups.

| Parameters (Kg/day) | Treatments | | | | SEM |
|---|---|---|---|---|---|
| | A | B | C | D | |
| DMI | 2.37$^a$ | 3.06$^b$ | 3.85$^c$ | 3.31$^d$ | 0.63 |
| OMI | 2.23$^a$ | 2.81$^b$ | 3.53$^c$ | 3.12$^d$ | 0.64 |
| CPI | 0.39$^a$ | 0.53$^{ab}$ | 0.91$^c$ | 0.65$^b$ | 0.64 |

Note: Different superscripts (a.b,c,d) in the same line showed significant differences (P<0.05)

## *Nutrient Digestibility*

The treatment of various forage sources and PKCC concentrates gave a significantly different effect (P<0.05) on the digestibility of dry matter, organic matter, and crude protein (Table 6). Treatment C revealed the highest dry matter digestibility (DMD) (76.85%) and organic matter digestibility (OMD) (77.25%) while the lowest was treatment A (69.43%). The range of crude protein digestibility (CPD) of the treatment was 71.26-86.01%. Also, treatment C showed the highest CPD

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(88.01%) while, treatment A appeared to have the lowest CPD (71.26%).

**Table 6**. Nutrient digestibility of the different experimental groups.

| Parameters (%) | Treatments A | B | C | D | SEM |
|---|---|---|---|---|---|
| Dry Matter Digestibility | 67.97$^{a}$ | 73.35$^{b}$ | 76.85$^{c}$ | 68.45$^{a}$ | 0.62 |
| Organic Matter Digestibility | 69.43$^{a}$ | 74.07$^{b}$ | 77.25$^{c}$ | 69.97$^{a}$ | 0.60 |
| Crude Protein Digestibility | 72.19$^{a}$ | 74.83$^{a}$ | 86.01$^{b}$ | 71.26$^{a}$ | 2.10 |

Note: Different superscripts (a,b,c,d) in the same line showed significant differences (P<0.05)

## Discussion

### *Milk Production*

Milk production in this study did not differ between treatments, but treatments that received various types of forage and PKCC+TW (B, C, and D) revealed higher milk production. Milk production is related to the proteinvalue of the ration. Rations B, C, and D contained highercrude protein. In the rumen, crude protein will be converted into $NH_3$. Rumen microbes utilized nitrogen from $NH_3$ for growth (Pazla *et al.*, 2021b). Optimal microbial growth increased microbial activity in fermenting polysaccharides and converted them into VFA (Suyitman *et al.*, 2021). VFA is the primary source of energy in ruminants. Optimal energy will optimize livestock productivity in milk production.

Although not statistically significant, milk production increased by replacing field grass with Tithonia, Gamal, and Cassava leave. This proves that Tithonia leaves, Cassava leaves, Gamal, and concentrate (PKCC+TW) could increase ECDG milk production. The higher milk production in treatments B, C, and D was in line with the crude protein content of the ration contributed from Tithonia, Cassava leaves, and Gamal, as well as PKCC+TW. Protein plays a significant role in maintaining mammary gland cells. The production of hormones and enzymes for milk biosynthesis is also strongly influenced by feed protein. Arief *et al.* (2018a) reported ECDG milk production of about 1.83 Kg/day which is different from the current study. The difference is due to the type of forage and concentrates used.

### *Milk Quality*

The value of milk protein in this study ranged from 4.89-6.26% and this value are higher than the normal range of 2.75-3% (SNI, 2011). Based on the Thai Agricultural Standard, this milk protein has been categorized as premium milk quality (TAS 6006, 2008). Treatments B and C with Tithonia forage, Cassava leaves, and PKCC+TW showed the highest milk protein. The increase in milk protein contents was caused by the combination of forages containing high protein (Tithonia and Cassava leaves) with PKCC+TW. Rations B and C can increase the supply of amino acids in the rumen to the intestine. Consumption of high-quality ration protein by ECDG is not all degraded in the rumen. Protein also enters the small intestine to be converted into amino acids. Amino acids are absorbed in the small intestine, flow through the circulatory system, and get into the

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udder. After that, the process continued with the synthesis of milk protein. The results of this study followJamarun *et al.* (2020a), who stated that dairy goats given high crude protein could increase milk protein.

Glucose and galactose are the constituent elements of lactose while the average lactose content in this study is about 3.44-6.73%. According to (SNI, 2011) the lactose content of milk is 2-3%. Ratya *et al.* (2017) reported that the lactose content of ECDG milk was 3.70-3.80. This study indicated that the lactose content of ECDG milk is still in the normal category, and some have the premium category. Treatment B (Tithonia + PKCC+TW) resulted in higher levels of lactose. Tithonia contains amino acids.The absorbed amino acids in the intestine were broken down into simple sugars. Gluconeogenesis in the liver will increase the glucose level in the blood so that the milk lactose level also rises. Zhang *et al.* (2018) stated that glucose is the main precursor in the formation of lactose in milk. High-soluble carbohydrates cause the substrate availability needed in the milk lactose synthesis process (Arief *et al.*, 2018b). Lactose in treatment B was not different from treatment A. Treatment A contained more concentrate (tofu waste). Tofu waste is feed ingredients classified as carbohydrates that are easily digested. Carbohydrates are converted to VFA (propionic acid). Propionic acid enters the process of gluconeogenesis. The blood immobilizes glucose in the udder gland to synthesize lactose in milk (Arief *et al.*, 2020).

The highest milk fat content was found in treatment B (Tithonia + PKCC + TW) and was not significantly different from treatment D (Gamal + PKCC +TW). Treatments A and C were also not critically different in the fat contents. The high-fat contents in treatment B were due to the consumption of crude fiber in the ration, which was higher than the other treatments. In addition, the increased milk fat contents are also influenced by high feed fat consumption. The fat in the rumen is converted into fatty acids (Makmur *et al.*, 2020). Fatty acids are the precursors in milk fat formation. ECDGs that consume feed with high-fat content tend to have high milk fat.

The SNF value of the ECDG treatment is about 13.30-15.01%. The lowest mean value was in the control treatment (A. The highest mean value was indicated by treatment B and followed by treatments C and D. These data indicated that the SNF of treated ECDG milk exceeded the standard. SNI (2011) stated that the SNF requirement for milk is 6-8%. The highest SNF was obtained due to the high protein and lactose content in treatment B. The rise of SNF level occurs due to the fat content that is not included in that section so the remaining protein and lactose levels can affect the high percentage produced. The high SNF in treatment B was also influenced by the high BJ value in the treatment compared to other treatments. Utari *et al.* (2012)reported that the SNF of goat milk-fed with a complete diet ranged from 10.33-11.61%. The difference is due to the high disparity between the dry matter and milk fat content.

Specific gravity is a derived quantity from the quotient of mass and volume. The specific gravity ofmilk can be used to determine the adulteration of milk added by coconut milk, and other ingredients that shouldnot be present in whole milk (Fitriansyah *et al.,* 2014). This study indicated that the average specific gravity of ECDG milk treatment with the highest average was obtained in treatment B, while the lowest average specific gravity was obtained in treatment A. The statistical analysis results showed that there was no significant between treatments on the milk-specific gravity. The specific gravity of milk was in the normal range, according to (SNI, 2011). Bhattarai (2012) stated that the specific gravity of goat's milk is higher than cow's milk. Changes in specific gravity are influenced bythe specific gravity of each component of milk consisting of protein, lactose, and fat.

Total solid is a description of the solid content in milk. Treatment B has the highest total solid, while treatment A shows the lowest total solid. The provisionof various types of forage and PKCC+TW on ECDG canproduce a total solid that is following (SNI, 2011) which is a minimum of 10.8%. The administration of various forage and PKCC+TW was significantly different ($P<0.05$) from the total solid.

The low total solid in treatment A was due to the lower nutritional quality in the treatment than other treatments. Treatment A only contained field grass and tofu waste. The difference between the total solid components between treatments occurred due to differences in the use of nutrients in the feed. Similarly, Arief *et al.,* (2021) stated that the total solid depends on the nutrients consumed by livestock. Nutrients will be used as precursors in the formation of solids in milk.

The pH value of milk in this study was 6.76-6.86. The value follows the standard of (TAS 6006, 2008) which is 6.5-6.8. The PH value is an indication of damage to milk. Different pH values can be caused by the content of freshly milked fresh milk such as $CO_2$, phosphate, citrate, and protein. Some of these compounds affect the ability of milk buffer. Milk buffer can inhibit milk's deterioration, which is induced by changes in the pH and acidity of milk (Zain, 2013). If there is bacterial activity, the pH value changes to acid (Swadayana *et al.,* 2012). A pH value above 6.7 usually indicates the possibility of mastitis (Legowo *et al.,* 2009).

The content of Ca and P in treatment A which only received feed ingredients from field grass and tofu waste was the lowest value. The nutritional quality of the given ration determines the minerals of the milk produced. Pazla *et al.,* (2021c) reported that the Ca and P content of Tithonia was richer than field grass, namely 0.99% Ca and 0.33% P, while field grass only contained 0.07% Ca and 0.09% P.

## *Feed Intake*

The replacement of field grass with various forages (Tithonia, Cassava leaves, and Gamal) and the replacement of tofu waste with PKCC can increase the dry matter intake (DMI). Treatments B, C, and D showed better DMI. Pazla *et al.,* (2018b) stated that high DMI indicated good palatability of feed ingredients. Good palatability encourages livestock to consume many nutrients. The performance of an animal will be more productive due to nutrition. Palatability is the most influential factor in the DMI of livestock. The DMI in this study showed a better percentage when compared to Isah *et al.,* (2015) with DMI values of 0.89 kg/head/day. Rosartio *et al.,* (2015) get a DMI that is almost the same as this study, which is 2.73-3.83 kg/head/day. The difference is due to the quality of the forage provided.

The highest DMI was found in treatment C with an average of 3.85 kg/head/day. Giving Cassava leaves up to 50% is still palatable for ECDG so their consumption increases. This is due to the goat's habit of "browsing" in search of food and its preference for leaves. The highest crude protein level in treatment C was also the factor causing the increase in DMI. Similarly, Suyitman *et al.,* (2020) state that the DMI of feed is influenced by feed digestibility, palatability, crude protein contents, and organic matter contents.

Treatment A showed the lowest DMI. The low intake in treatment A was caused by the forage given. Field grass has low nutrient contents and palatability compared to forages in other treatments.

The intake pattern of organic matter follows the pattern of DMI. Dry matter is the main component in addition to water content in animal feed ingredients, while the organic matter is part of dry matter. The increase in DMI impacted the rise of OMI as reported by(Febrina *et al.*, 2017). The average OMI during the studyranged from 2.23-3.53 Kg/e/h. The OMI in treatment A was significantly lower than in the other treatments. LowOMC is caused by low DMI.

Crude protein intake in treatments B, C, and D showed a higher value. Treatment C which got Cassava leaf forage revealed the highest value (0.91 kg/head/day). The crude protein content of Cassava leaves is also higher than other forages. CPI is strongly influenced by the crude protein content of feed ingredients. In addition, DMI was also the factor causing the rise of CPI in treatment C. Likewise, Arief *et al.* (2021b) stated that the CPI was influenced by the protein content in the ration. The high CPI will affect the high utilization of feed protein for production needs. Giving Cassava leaves can increase the CPI.

Marwah *et al.,* (2010) found a lower CPI than the CPI in this study, which was 0.34 kg/head/day. The difference is due to the distinct types of forage and concentrates given to ECDG. The ration in a recent study was superior because the forage provided had high protein and concentrate with more diverse components.

The anti-nutritional effect of Tithonia, Cassava, and Gamal leaves up to 50% in the ration has not been seen in reducing feed intake. This proves that up to a level of 50%, the provision of Tithonia, Cassava, and Gamal in rations is safe for livestock. Several studies on Tithonia, Cassava, and Gamal added to the ration mix did notaffect the productivity and digestibility of ruminants if the dose was not excessive (Jamarun *et al.,* 2020b).

### *Nutrient Digestibility*

The treatment of various forage sources and PKCC+TW concentrates gave a significantly different effect on the digestibility of dry matter, organic matter, and crude protein. ECDG that received Cassava leaf forage and PKC concentrate revealed higher digestibility than the goats that were given field grass, Tithonia, and Gamal. This means that cassava leaves can play a role in increasing digestibility.

Whether or not the quality of a ration given to livestock can be seen from the percentage of DMD. The higher the DMD, the higher the opportunity for nutrients utilized by livestock for growth and production. Odedire dan Oloidi (2014) obtained lower DMD scores than this study, which was 70.98%. Isah *et al.,* (2015) got the higher DMD which was 754%. The difference in DMD is due to the type and nutritional content of the rations given.

The average DMD value of the treatment ration increased with the provision of tithonia forage, Cassava leaves, and PKC concentrate. In this case, this is due to the better nutritional content of the ration. The percentage of OMD in this study ranged from 69.43 to 77.25%. The treatment of various forages and PKC- based concentrates had a significant effect on OMD. Treatment C got the highest OMD (77.25%) while the lowest was treatment A (69.43%). The OMD value increased along with the rise of the DMD. Jamarun *et al.* (2018c) reported that the pattern of OMD is related to DMD. Most of the dry matter content is digestible organic matter such as carbohydrates, proteins, and fats.

The range of crude protein digestibility of the treatment was 71.26-86.01%. Treatment C got the highest CPD (88.01%) while treatment A got the lowest CPD (71.26%). The chemical composition of feed ingredients dramatically affects the level of digestibility. The quality of the ration is proportional to the digestibility of crude protein. CPD is also associated with the consumption of crude protein. High crude protein consumption will result in high crude proteindigestibility. Putri *et al.* (2021) stated that crude protein digestibility is influenced by microbial protein synthesis. Microbial protein synthesis will increase along with the rise in ration protein (Pazla *et al.,* 2018c).

The treatment of giving various forages and PKC+TW concentrates had a significant effect on the increase in CPD. This means that the application of Tithonia, Cassava, and Gamal up to 50% could maintain the CPD. Crude protein digestibility is highly dependent on the performance of proteolytic bacteria. Proteolytic bacteria are bacteria that produce extracellular protease enzymes that will break down protein in feed. The significant difference between treatments was due to different proportions of proteolytic bacteria in each treatment. The CPD in this study was higher than Supriyati and Haryanto (2011), who obtained a CPD of the combination of elephant grass and palm kernel cake of 73.027% - 75.99%. The difference is due to the feed ingredients which are concentrate and forage.

## Conclusion

Replacement of field grass with various forage sources and replacement of tofu waste with concentrate- based palm kernel cake could increase feed consumption and digestibility, as well as increases protein, lactose, and fat of milk.

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## Author Contribution

**Arief:** Designed the research plan, and organized and supervised the study.

**Roni Pazla:** Conducted the research, analyzed data, and contributed to the writing of the manuscript.

## Conflict of Interest

The authors declare that they have no conflict of interest.

## Ethics

This article is original and has never been published before. The author has also confirmed to all authors involved in this study to read and agree to the contents of this article and that there are no ethical issues involved.

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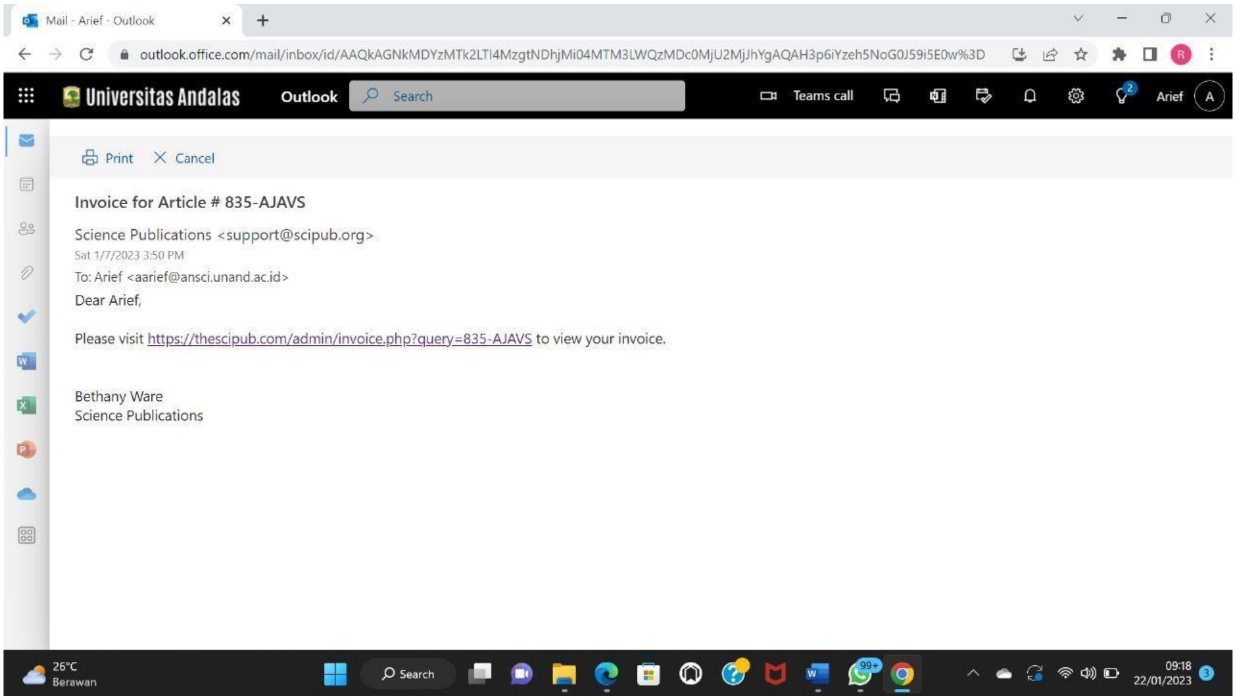

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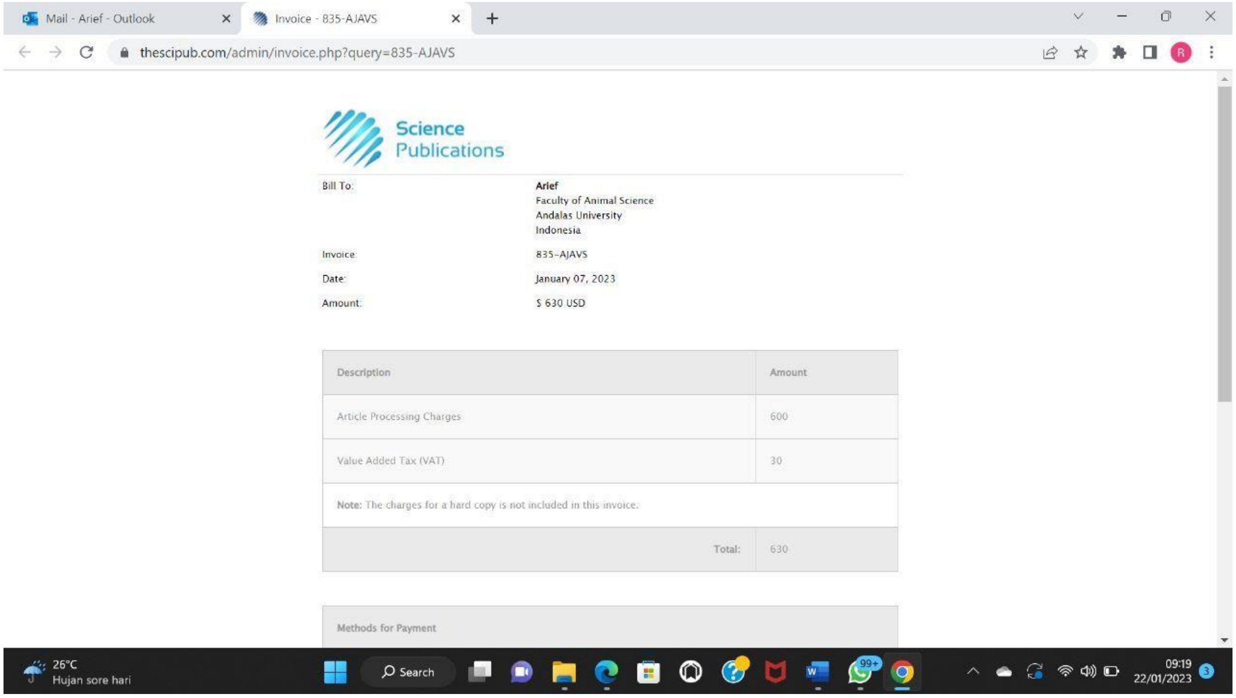
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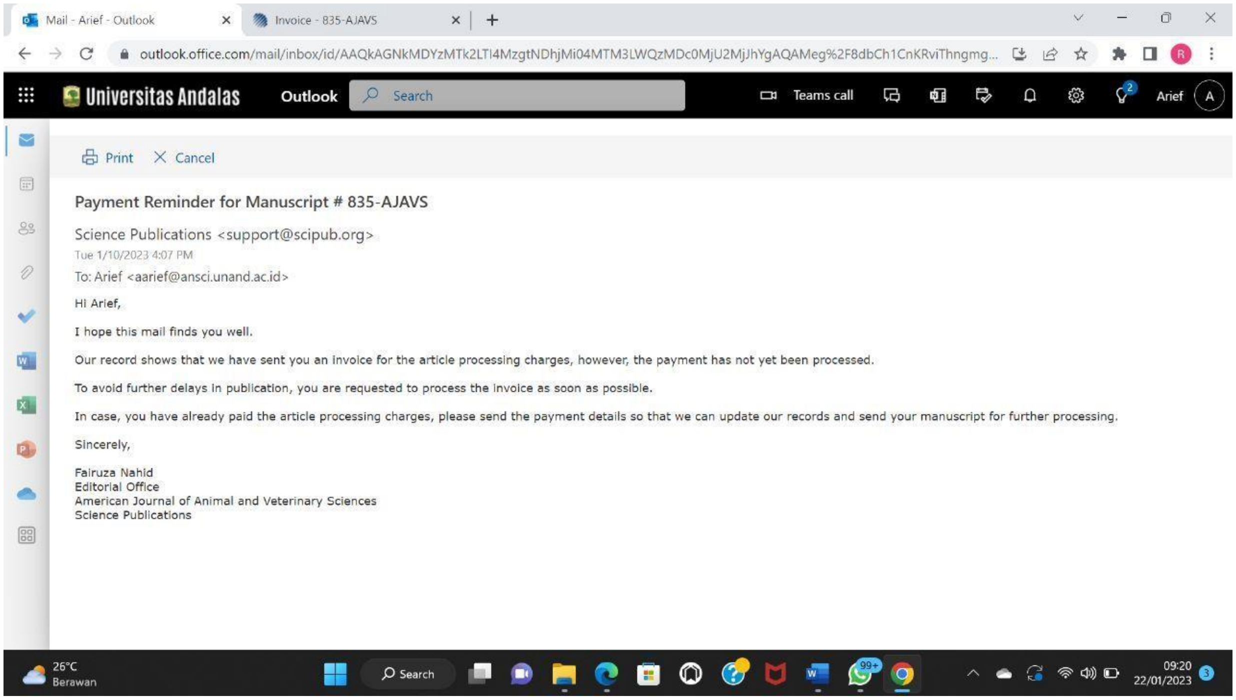

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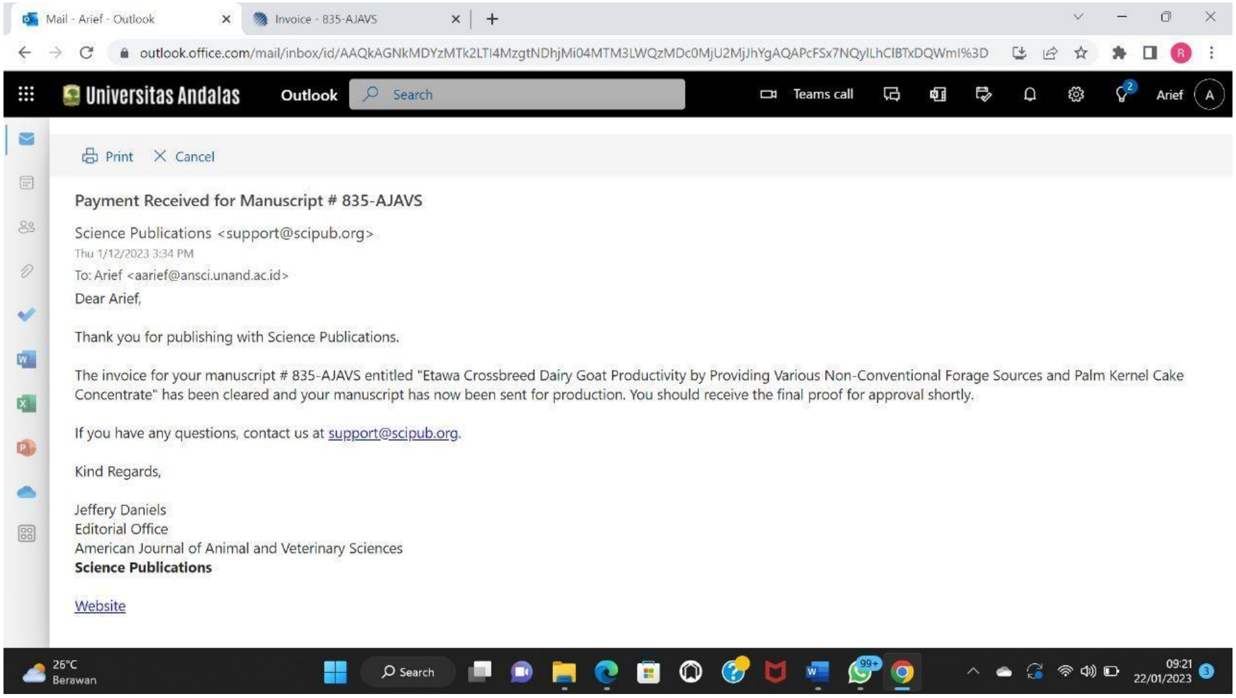
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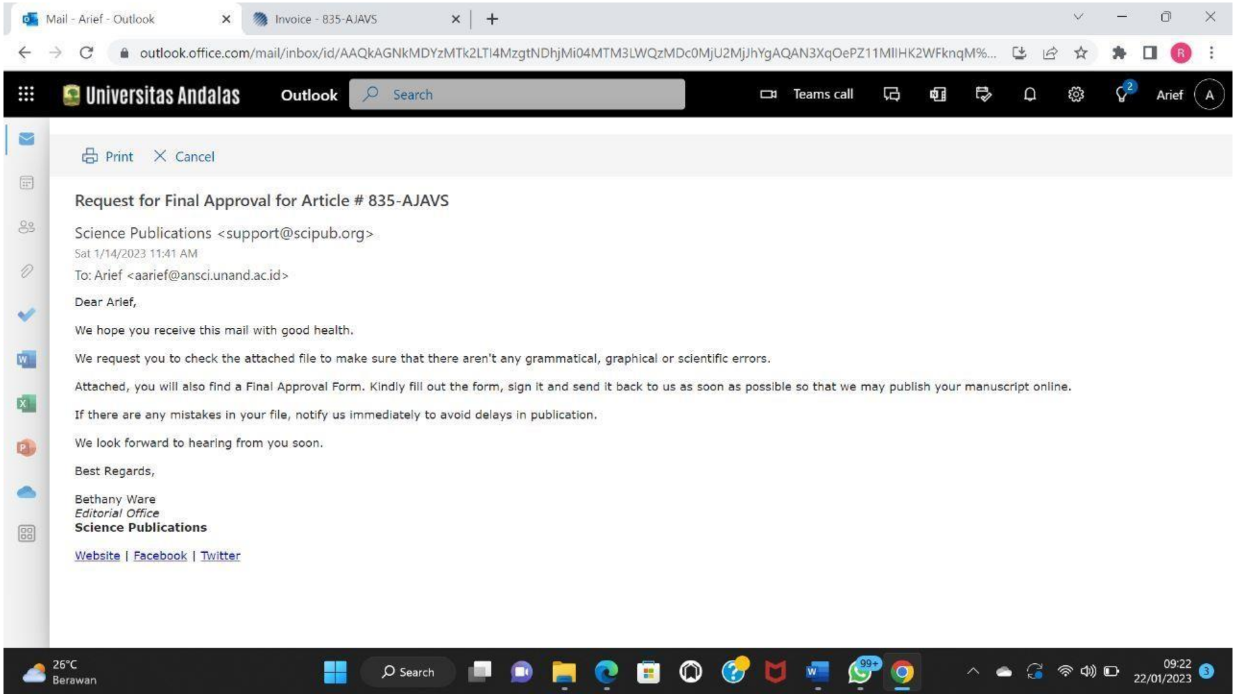

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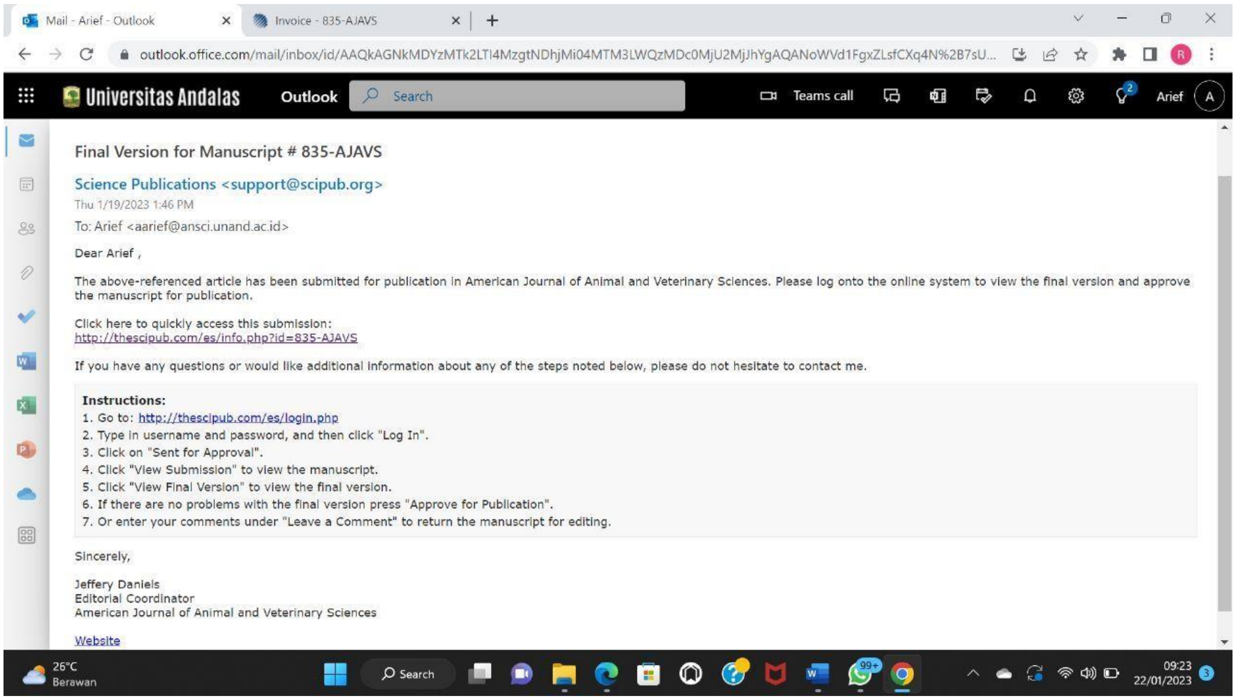

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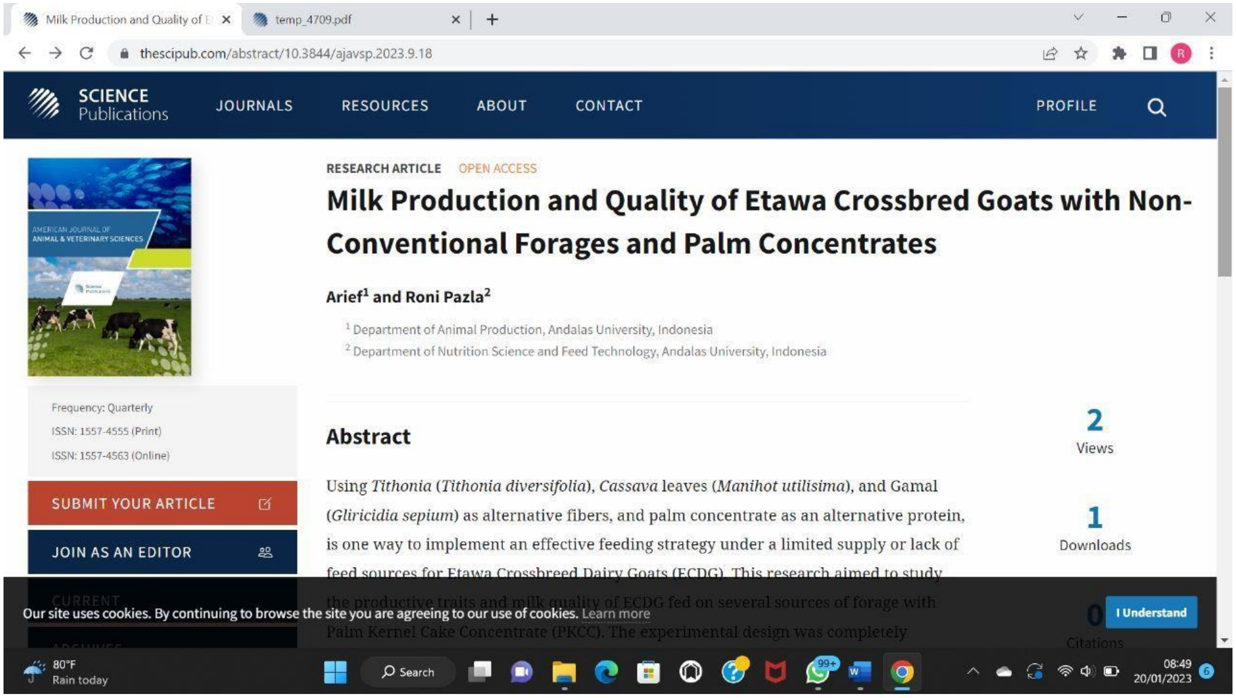

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Original Research Paper

# Milk Production and Quality of Etawa Crossbred Goats with Non-Conventional Forages and Palm Concentrates

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**Abstract:** Using *Tithonia* (*Tithonia diversifolia*), *Cassava* leaves (*Manihot utilisima*), and Gamal (*Gliricidia sepium*) as alternative fibers, and palm concentrate as an alternative protein, is one way to implement an effective feeding strategy under a limited supply or lack of feed sources for Etawa Crossbreed Dairy Goats (ECDG). This research aimed to study the productive traits and milk quality of ECDG fed on several sources of forage with Palm Kernel Cake Concentrate (PKCC). The experimental design was completely randomized with four treatments of feed formulation. Treatment formulations were as follows: A. 50% Tofu Waste (TW) +50% field grass (control); B. 25% TW +25% PKCC +50% *Tithonia* (*Tithonia diversifolia*); C. 25% TW +25% PKCC +50% *Cassava* leaves (*Manihot utilisima*); D. 25% TW +25% PKCC +50% Gamal (*Gliricidia sepium*). The results showed were significant ($P<0.05$) on parameters such as DMI, OMI, CPI, DMD, OMD, CPD, protein, lactose, fat, TS, and Ca of milk. It can be concluded that the replacement of field grass with forage sources such as *Tithonia*, *Cassava* leaves, and Gamal and the replacement of tofu waste with concentrate-based palm kernel cake could increase feed intake, digestibility, protein, lactose, and fat of milk.

**Keywords:** Goat, Forage, Milk, Nutrition, Palm Concentrate

## Introduction

Forage such as elephant grass is the main feed for ruminants to provide crude fiber. Other unconventional forage sources are *Tithonia* (*Tithonia diversifolia*), *Cassava* leaves (*Manihot utilisima*), and Gamal (*Gliricidia sepium*) were suggested. *Tithonia* is a shrub or weed-like plant that grows a lot in an empty land, roadsides, and rice fields. In West Sumatra, *Tithonia* is also known as the paitan plant because of its bitter leaves (Pazla *et al*., 2021a). *Tithonia* plants have not been widely used as a source of organic matter, fertilizer, or animal feed ingredients. However, *Tithonia* is quite favored by livestock because of its high protein content of up to 22.98% (Jamarun *et al*., 2019). Also, *Cassava* leaves and Gamal are nutritious foraged ingredients that are useful for livestock.

Furthermore, livestock needs concentrated feed ingredients for energy. The prices of concentrate ingredients, especially corn, are expensive. Therefore, it is necessary to look for alternative feed ingredients with abundant availability and quality to reduce dependence on imported feed ingredients. One of the concentrate feed ingredients is a by-product of the palm oil processing industry, namely Palm Kernel Cake (PKC). Viewed from the production aspect, 60% of the total palm oil industry products are by-products. PKC is useful as an alternative feed ingredient for livestock because it has good nutritional composition and great potential as a source of concentrated feed ingredients for livestock (Arief *et al*., 2019a).

In addition to dairy goats, livestock that can be developed as milk-producing is Etawa Crossbred Dairy Goats (ECDG). The ECDG crosses between Etawa goats and Indonesian kacang goats. The advantage of ECDG is that they have good adaptability to the different environmental macroclimatic conditions in Indonesia. ECDG are dual-purpose type goats that have good reproductive characteristics and better nutritional milk content than cow's milk (Arief *et al*., 2019b). ECDG is raised for milk production, especially in Indonesia (Arief *et al*., 2021a-b). Goat's milk contains minerals such as Ca, P, and Mg which are higher than cow's and human milk. The high content of medium-chain fatty acids is beneficial for the body because it is rapidly oxidized by the liver and induces a full effect (Vaquil, 2017). Besides, goat's milk has medicinal properties that can cure various diseases such as asthma and tuberculosis (Pal *et al*., 2011).

Research on the use of various forage sources combined with the provision of by-products from the palm oil industry and tofu waste as feed ingredients for lactating ECDG concentrates has never been carried out. If this potential is explored properly, non-conventional forage sources and the palm oil industry will play a significant role in providing animal feed, especially dairy goats, which are useful for supporting food self-sufficiency programs, especially milk in Indonesia (Pazla *et al*., 2018a).

This research aimed to study the productive traits and milk quality of ECDG fed on several sources of forage with Palm Kernel Cake Concentrate (PKCC).

## Materials and Methods

### *Ethical Approval*

This experiment has referred to research ethics using livestock based on the Republic of Indonesia government law number 18 of 2009 (Section 66), which addressed animal keeping, raising, killing, and proper treatment and care.

### *Experimental Design and Duration*

This research was conducted at an ECDG livestock company in Payakumbuh, West Sumatra, Indonesia (-0.2330638,100.6268024). There were 16 ECDGs in the second month of lactation used in this research. The selected ECDG at 1-1.5 years and 58-60 kg. All zoo hygiene requirements are met in intensive goat farming (Hasan *et al*., 2022).

This experiment used a $4 \times 4$ completely randomized design determined by four treatments of feed formulation as follows: A. 50% Tofu Waste (TW) +50% field grass (control); B. 25% TW +25% Kernel Cake Concentrate (PKCC) +50% *Tithonia*; C. 25% TW +25% PKCC +50% *Cassava* leaves; D.25% TW +25% PKCC +50% Gamal for a total of 16 experimental units. ECDGs were placed in individual cages with a size of $1.25 \times 1.00$ m. The experimental cage was given disinfectant (anti-microorganism) to inhibit and kill microorganisms and all ECDG were given deworming before the study started. All ECDGs were confirmed not to have mastitis. The experiment was carried out for 50 days consisting of 30 days of the adaptation period, 15 days of the preliminary period, and 5 days of the collecting period.

The experimental ration consisted of forage and concentrate in a ratio of 50:50. The ration was given at 3.5% of body weight-based dry matter (NRC, 2007). Drinking water was available ad libitum. The nutritional contents of each feed ingredient are presented in Table 1. The composition and nutritional contents of palm kernel cake-based concentrates are presented in Table 2. The composition and nutritional contents of the experimental rations are explained in Table 3. Proximate analysis of feed ingredients (dry matter, ash, protein, extract ether, and crude fiber) was carried out following (AOAC, 2005). NDF was determined following (Goering, 1970). TDN was estimated with the following formula (Moran, 2005):

$$TDN = 5.31 + 0.412\ CP\% + 0.249\ CF\% + 1.444\ EE\% + 0.937\ NFE\%$$

where:
*CP* = Crude Protein
*CF* = Crude Fiber
*EE* = Extract Ether
*NFE* = Nitrogen Free Extract

### *Collection of Fecal Samples*

The sewage collection ($n$ = 16) from the ECDG was carried out for 5 days from the 46$^{th}$ day to the 50$^{th}$ day. The dirt was weighed every day at 8 am (the weight of fresh dirt). Then 200 g of dirt was taken as a sample to analyze the dry matter, ash, and crude protein content. Thesamples were oven to 60°C for 8 h and then weighed (dryweight). Before analysis in the laboratory, goat hair attached to the manure was removed.

### *Milk Sample Collection*

Every day, the milk production of each experimental animal was weighed and recorded. Milk samples ($n$ = 16) were taken 2 times during the studyfor quality testing as much as 300 mL per treatment goat. Before sampling, the nipples were cleaned so that the dirt that sticks out can be lost and not contaminate the milk. Then, the milk sample was taken and storedin a cool box to avoid microbial contamination.

### *Parameters Measured*

The variables measured were Dry Matter Intake (DMI), Organic Matter Intake (OMI), Crude Protein Intake (CPI), Dry Matter Digestibility (DMD), Organic Matter Digestibility (OMD), Crude Protein Digestibility (CPD), milk production and milk quality parameters such as milk protein, lactose, milk fat, Total Solid (TS), Solid Non-Fat (SNF), pH, BJ and Ca and P mineral. Digestibility measurement *in vivo* using the total collection method (Jamarun *et al*., 2021): Weighing the entire ration eaten and weighing all excreted feces.

Protein, lactose, and fat were measured using the method of (AOAC, 2005), SNF and TS were measured using lactoscan MCC50, pH was measured using a pH meter digital HI9807-phep, Singapura, while specific grafity was measured using a lactodensimeter merk funke gerber Germany.

**Table 1:** The nutritional content of ea h feed ingredient

| | Feedstuff | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nutrient (%) | Fields grass | T | CL | G | Rice bran | Tofu waste | PKC | Corn |
| Dry matter | 23.29 | 25.57 | 31.10 | 21.42 | 87.80 | 28.40 | 91.83 | 85.80 |
| Organic matter | 92.41 | 84.01 | 89.85 | 94.85 | 90.80 | 97.67 | 91.41 | 99.10 |
| Protein | 10.23 | 22.98 | 27.15 | 19.11 | 10.72 | 20.11 | 12,36.00 | 7.70 |
| Crude fiber | 25.44 | 18.17 | 19.12 | 19.75 | 11.60 | 19.00 | 26.68 | 2.44 |
| Extract ether | 3.64 | 04.71 | 3.52 | 2.98 | 08.73 | 01.25 | 8.23 | 3.50 |
| NFE | 53.10 | 38.15 | 39.26 | 53.01 | 59.75 | 57.31 | 44.14 | 85.46 |
| NDF | 67.20 | 55.03 | 56.13 | 46.33 | 55.13 | 59.28 | 66.70 | 49.96 |
| TDN | 58.65 | 62.60 | 79.21 | 67.60 | 66.63 | 74.61 | 65.40 | 81.90 |

Note: T = *Tithonia*, CL = *Cassava* Leaf, G = Gamal, PKC = Palm Kernel Cake, NFE = Nitrogen Free Extract, NDF = Neutral Detergent Fiber, TDN = Total Digestible Nutrient

**Table 2:** The composition and nutrients of palm kernel cake concentrate (% DM)

| Feed ingredients | Level (%) |
|---|---|
| Palm kernel cake | 40.00 |
| Rice bran | 20.00 |
| Corn | 9.00 |
| Tofu waste | 30.00 |
| Ultra mineral | 1.00 |
| Nutrient | Percentage (%) |
| Dry matter | 91.84 |
| Ash | 9.88 |
| Crude protein | 16.88 |
| Crude fiber | 13.22 |
| NFE | 55.06 |
| NDF | 62.84 |
| TDN | 66.36 |

Note: NFE = Nitrogen Free Extract, NDF = Neutral Detergent Fiber, TDN = Total Digestible Nutrient

**Table 3:** Composition of treatments ration (%)

| | Treatments | | | |
|---|---|---|---|---|
| Feed materials | A | B | C | D |
| Field grass | 50 | 0 | 0 | 0 |
| *Tithonia* | - | 50 | 0 | 0 |
| *Cassava* | - | - | 50 | 0 |
| Gamal | - | - | 0 | 50 |
| PKCC | - | 25 | 25 | 25 |
| Tofu waste | 50 | 25 | 25 | 25 |
| Total | 100 | 100 | 100 | 100 |

### *Statistical Analysis*

Experimental data were analyzed using the Analysis of Variance (ANOVA) with a completely randomized design (Steel and Torrie, 1980) using SPSS software version 20. Parameters mean showed statistical differences in probabilities level of P<0.05 compared using the Duncan multiple range tests. The statistical model and experimental design were as follows:

$$Y_{ij} = \mu + M_i + \varepsilon_{ij}$$

where, $Y_{ij}$ denotes the observation variable, $\mu$ denotes the overall mean, $M_i$ denotes the effect of treatments and $\varepsilon_{ij}$ denotes the residual effect.

## Results

### *Milk Production*

The quality of feed greatly determines the optimal production and quality of milk. Milk production in this study did not differ between treatments, but treatments that received various types of forage (*Tithonia*, *Cassava* leaves, and Gamal) and PKCC showed higher milk production (Fig. 1) and no relationship between them. crude protein intake and milk production (Fig. 2).

### *Milk Quality*

The results on the quality of ECDG goat milk showed that treatment C had the highest milk protein contents (Table 4) which was not significantly different from treatments B and D. Treatment B resulted in higher levels of lactose (P<0.05). The highest milk fat content was found in treatment B which was not significantly different from treatment D. The highest SNF was obtained due to the high protein and lactose contents in treatment B. The statistical analysis showed that there was no significant difference between treatments on the specific gravity of milk. Treatment B had the highest total solid, 21.78% and treatment A exhibited the lowest total solid up to 16.87%. The pH value of milk in this study was 6.76-6.86. The contents of Ca and P in treatment A expose the lowest value when compared to treatments B, C, and D, which received ingredients from *Tithonia* forage, *Cassava* leaves, and Gamal, as well as PKCC.

### *Feed Intake*

The replacement of field grass with various forages (*Tithonia*, *Cassava* leaves, and Gamal) and the replacement of tofu waste with PKCC could increase (P<0.05) the Dry Matter Intake (DMI) (Table 5). Treatments B, C, and D revealed better DMI. The average Organic Matter Intake (OMI) during the study ranged from 2.23-3.53 Kg/e/h. The OMI in treatment A was significantly (P<0.05) lower than the other treatments. Crude Protein Intake (CPI) in treatments B, C, and D indicated a higher value (P<0.05). Treatment C exhibited the highest value (0.91 kg/head/day).

### *Nutrient Digestibility*

The treatment of various forage sources and PKCC concentrates gave a significantly different effect (P<0.05) on the digestibility of dry matter, organic matter, and crude protein (Table 6). Treatment C revealed the highest Dry Matter Digestibility (DMD) (76.85%) and Organic Matter Digestibility (OMD)(77.25%) while the lowest was treatment A (69.43%). The range of Crude Protein Digestibility (CPD) of the treatment was 71.26-86.01%. Also, treatment C showed the highest CPD (88.01%) while, treatment A appeared to have the lowest CPD (71.26%).

**Table 4:** Milk quality of the different experimental groups

| | Treatments | | | | |
|---|---|---|---|---|---|
| Parameters | A | B | C | D | SEM |
| Protein (%) | 4.89$^{a}$ | 5.99$^{b}$ | 6.26$^{b}$ | 6.01$^{b}$ | 0.2500 |
| Lactose (%) | 5.58$^{a}$ | 6.73$^{a}$ | 3.55$^{b}$ | 3.44$^{b}$ | 0.5400 |
| Fat (%) | 3.58$^{a}$ | 6.78$^{b}$ | 3.70$^{a}$ | 6.05$^{b}$ | 0.3400 |
| Solid Non-Fat (SNF) (%) | 13.30 | 15.01 | 13.92 | 13.79 | 0.6000 |
| Total Solid (TS) (%) | 16.87$^{a}$ | 21.78$^{c}$ | 17.62$^{ab}$ | 19.84$^{bc}$ | 0.8100 |
| pH | 6.8600 | 6.7800 | 6.7600 | 6.8100 | 0.0400 |
| Specific gravity (g/cm$^3$) | 1.0285 | 1.0289 | 1.0288 | 1.0288 | 0.0002 |
| Ca (%) | 0.34$^{a}$ | 0.47$^{b}$ | 0.56$^{c}$ | 0.73$^{d}$ | 0.1800 |
| P (%) | 0.2300 | 0.2700 | 0.2900 | 0.2600 | 0.2400 |

Note: Different superscripts (a, b, c, d) in the same line showed significant differences (P<0.05)

**Table 5:** Feed intake of the different experimental groups

| | Treatments | | | | |
|---|---|---|---|---|---|
| Parameters (Kg/day) | A | B | C | D | SEM |
| DMI | 2.37$^{a}$ | 3.06$^{b}$ | 3.85$^{c}$ | 3.31$^{d}$ | 0.63 |
| OMI | 2.23$^{a}$ | 2.81$^{b}$ | 3.53$^{c}$ | 3.12$^{d}$ | 0.64 |
| CPI | 0.39$^{a}$ | 0.53$^{ab}$ | 0.91$^{c}$ | 0.65$^{b}$ | 0.64 |

Note: Different superscripts (a.b,c,d) in the same line showed significant differences (P<0.05)

**Table 6:** Nutrient digestibility of the different experimental groups

| | Treatments | | | | |
|---|---|---|---|---|---|
| Parameters (%) | A | B | C | D | SEM |
| Dry matter digestibility | 67.97$^{a}$ | 73.35$^{b}$ | 76.85$^{c}$ | 68.45$^{a}$ | 0.62 |
| Organic matter digestibility | 69.43$^{a}$ | 74.07$^{b}$ | 77.25$^{c}$ | 69.97$^{a}$ | 0.60 |
| Crude protein digestibility | 72.19$^{a}$ | 74.83$^{a}$ | 86.01$^{b}$ | 71.26$^{a}$ | 2.10 |

Note: Different superscripts (a, b, c, d) in the same line showed significant differences (P<0.05)

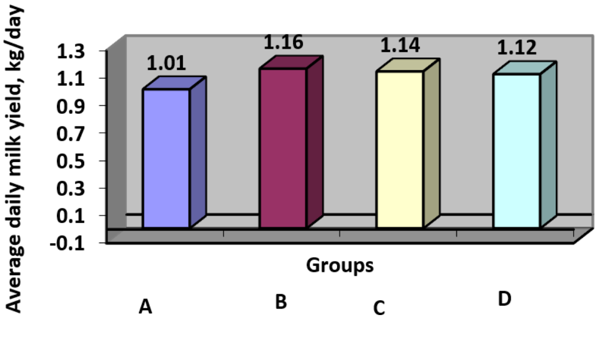


**Fig. 1:** Milk production as affected by treatments, kg/d

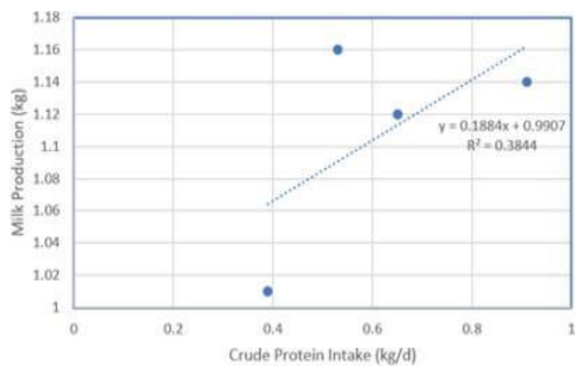


**Fig. 2:** Relationship between crude protein intake and milk production

## Discussion

### *Milk Production*

Milk production in this study did not differ between treatments, but treatments that received various types of forage and PKCC + TW (B, C, and D) revealed higher milk production. Milk production is related to the protein value of the ration. Rations B, C, and D contained higher crude protein. In the rumen, crude protein will be converted into $NH_3$. Rumen microbes utilized nitrogen from $NH_3$ for growth (Pazla *et al*., 2021b). Optimal microbial growth increased microbial activity in fermenting polysaccharides and converted them into VFA (Suyitman *et al*., 2021). VFA is the primary source of energy in ruminants. Optimal energy will optimize livestock productivity in milk production.

Although not statistically significant, milk production increased by replacing field grass with *Tithonia*, Gamal and *Cassava* leave. This proves that *Tithonia* leaves, *Cassava* leaves, Gamal and concentrate (PKCC + TW) could increase ECDG milk production. The higher milk production in treatments B, C, and D was in line with the crude protein content of the ration contributed from *Tithonia*, *Cassava* leaves, and Gamal, as well as PKCC + TW. Protein plays a significant role in maintaining mammary gland cells. The production of hormones and enzymes for milk biosynthesis is also strongly influenced by feed protein. Arief *et al.* (2018a) reported ECDG milk production of about 1.83 Kg/day which is different from the current study. The difference is due to the type of forage and concentrates used.

### *Milk Quality*

The value of milk protein in this study ranged from 4.89-6.26% and this value is higher than the normal range of 2.75-3% (SNI, 2011). Based on the Thai agricultural standard, this milk protein has been categorized as premium milk quality (TAS, 2008). Treatments B and C with *Tithonia* forage, *Cassava* leaves, and PKCC + TW showed the highest milk protein. The increase in milk protein contents was caused by the combination of forages containing high protein (*Tithonia* and *Cassava* leaves) with PKCC + TW. Rations B and C can increase the supply of amino acids in the rumen to the intestine. Consumption of high-quality ration protein by ECDG is not all degraded in the rumen. Protein also enters the small intestine to be converted into amino acids. Amino acids are absorbed in the small intestine, flow through the circulatory system and get into the udder. After that, the process continued with the synthesis of milk protein. The results of this study follow (Jamarun *et al*., 2020a), who stated that dairy goats given high crude protein could increase milk protein.

Glucose and galactose are the constituent elements of lactose while the average lactose content in this study is about 3.44-6.73%. According to SNI (2011) the lactose content of milk is 2-3%. Ratya *et al.* (2017) reported that the lactose content of ECDG milk was 3.70-3.80. This study indicated that the lactose content of ECDG milk is still in the normal category and some have the premium category. Treatment B (*Tithonia* + PKCC + TW) resulted in higher levels of lactose. *Tithonia* contains amino acids. The absorbed amino acids in the intestine were broken down into simple sugars. Gluconeogenesis in the liver will increase the glucose level in the blood so that the milk lactose level also rises. Zhang *et al.* (2018) stated that glucose is the main precursor in the formation of lactose in milk. High-soluble carbohydrates cause the substrate availability needed in the milk lactose synthesis process (Arief *et al*., 2018b). Lactose in treatment B was not different from treatment A. Treatment A contained more concentrate (tofu waste). Tofu waste is feed ingredients classified as carbohydrates that are easily digested. Carbohydrates are converted to VFA (propionic acid). Propionic acid enters the process of gluconeogenesis. The blood immobilizes glucose in the udder gland to synthesize lactose in milk (Arief *et al*., 2020).

The highest milk fat content was found in treatment B (*Tithonia* + PKCC + TW) and was not significantly different from treatment D (Gamal + PKCC + TW). Treatments A and C were also not critically different in the fat contents. The high-fat contents in treatment B were due to the consumption of crude fiber in the ration, which was higher than the other treatments. In addition, the increased milk fat contents are also influenced by high feed fat consumption. The fat in the rumen is converted into fatty acids (Makmur *et al*., 2020). Fatty acids are the precursors in milk fat formation. ECDGs that consume feed with high-fat content tend to have high milk fat.

The SNF value of the ECDG treatment is about 13.30-15.01%. The lowest mean value was in the control treatment (A. The highest mean value was indicated by treatment B and followed by treatments C and D. These data indicated that the SNF of treated ECDG milk exceeded the standard. SNI (2011) stated that the SNF requirement for milk is 6-8%. The highest SNF was obtained due to the high protein and lactose content in treatment B. The rise of SNF level occurs due to the fat content that is not included in that section so the remaining protein and lactose levels can affect the high percentage produced. The high SNF in treatment B was also influenced by the high BJ value in the treatment compared to other treatments. Utari *et al.* (2012) reportedthat the SNF of goat milk-fed with a complete diet rangedfrom 10.33-11.61%. The difference is due to the high disparity between the dry matter and milk fat content.

Specific gravity is a derived quantity from the quotient of mass and volume. The specific gravity of milk can be used to determine the adulteration of milk added by coconut milk and other ingredients that should not be present in whole milk (Fitriansyah *et al*., 2014). This study indicated that the average specific gravity of ECDG milk treatment with the highest average was obtained in treatment B, while the lowest average specific gravity was obtained in treatment A. The statistical analysis results showed that there was no significant between treatments on the milk-specific gravity. The specific gravity of milk was in the normal range, according to (SNI, 2011). Bhattarai (2012) stated that the specific gravity of goat's milk is higher than cow's milk. Changes in specific gravity are influenced by the specific gravity of each component of milk consisting of protein, lactose, and fat.

Total solid is a description of the solid content in milk. Treatment B has the highest total solid, while treatment A shows the lowest total solid. The provision of various types of forage and PKCC + TW on ECDG can produce a total solid that is following (SNI, 2011) which is a minimum of 10.8%. The administration of various forage and PKCC + TW was significantly different ($P<0.05$) from the total solid.

The low total solid in treatment A was due to the lower nutritional quality in the treatment than other treatments. Treatment A only contained field grass and tofu waste. The difference between the total solid components between treatments occurred due to differences in the use of nutrients in the feed. Similarly, Jamarun *et al.*, (2021) stated that the total solid depends on the nutrients consumed by livestock. Nutrients will be used as precursors in the formation of solids in milk.

The pH value of milk in this study was 6.76-6.86. The value follows the standard of (TAS, 2008) whichis 6.5-6.8. The pH value is an indication of damage to milk. Different pH values can be caused by the content offreshly milked fresh milk such as $CO_2$, phosphate, citrate, and protein. Some of these compounds affect the ability of milk buffer. Milk buffer can inhibit milk's deterioration, which is induced by changes in the pH and acidity of milk (Zain, 2013). If there is bacterial activity, the pH value changes to acid (Swadayana *et al.*, 2012). ApH value above 6.7 usually indicates the possibility of mastitis (Legowo and Kusrahayu, 2009).

The content of Ca and P in treatment A which only received feed ingredients from field grass and tofu waste was the lowest value. The nutritional quality of the given ration determines the minerals of the milk produced. Pazla *et al*. (2021c) reported that the Ca and P content of *Tithonia* was richer than field grass, namely 0.99% Ca and 0.33% P, while field grass only contained 0.07% Ca and 0.09% P.

### *Feed Intake*

The replacement of field grass with various forages (*Tithonia*, *Cassava* leaves, and Gamal) and the replacement of tofu waste with PKCC can increase the Dry Matter Intake (DMI). Treatments B, C, and D showed better DMI. Pazla *et al*. (2018b) stated that high DMI indicated good palatability of feed ingredients. Good palatability encourages livestock to consume many nutrients. The performance of an animal will be more productive due to nutrition. Palatability is the most influential factor in the DMI of livestock. The DMI in this study showed a better percentage when compared to (Isah *et al*., 2015) with DMI values of 0.89 kg/head/day. Rosartio *et al.* (2015) get a DMI that is almost the same as this study, which is 2.73-3.83 kg/head/day. The difference is due to the quality of the forage provided.

The highest DMI was found in treatment C with an average of 3.85 kg/head/day. Giving *Cassava* leaves up to 50% is still palatable for ECDG so their consumption increases. This is due to the goat's habit of "browsing" in search of food and its preference for leaves. The highest crude protein level in treatment C was also the factor causing the increase in DMI. Similarly, (Suyitman *et al*., 2020) state that the DMI of feed is influenced by feed digestibility, palatability, crude protein contents, and organic matter contents.

Treatment A showed the lowest DMI. The low intake in treatment A was caused by the forage given. Field grass has low nutrient contents and palatability compared to forages in other treatments.

The intake pattern of organic matter follows the pattern of DMI. Dry matter is the main component in addition to water content in animal feed ingredients, while organic matter is part of dry matter. The increase in DMI impacted the rise of OMI as reported by Febrina *et al.* (2017). The average OMI during the study ranged from 2.23-3.53 Kg/e/h. The OMI in treatment A was significantly lower than in the other treatments. Low OMC is caused by low DMI.

Crude protein intake in treatments B, C, and D showed a higher value. Treatment C which got *Cassava* leafforage revealed the highest value (0.91 kg/head/day). The crude protein content of *Cassava* leaves is also higher than other forages. CPI is strongly influenced by the crude protein content of feed ingredients. In addition, DMI was also the factor causing the rise of CPI in treatment C. Likewise, (Jamarun *et al*., 2021)stated that the CPI was influenced by the protein content in the ration. The high CPI will affect the high utilization of feed protein for production needs. Giving *Cassava* leaves can increase the CPI.

Marwah *et al*. (2010) found a lower CPI than the CPI in this study, which was 0.34 kg/head/day. The difference is due to the distinct types of forage and concentrates given to ECDG. The ration in a recent study was superior because the forage provided had high protein and concentrate with more diverse components.

The anti-nutritional effect of *Tithonia*, *Cassava*, and Gamal leaves up to 50% in the ration has not been seen in reducing feed intake. This proves that up to a level of 50%, the provision of *Tithonia*, *Cassava*, and Gamal in rations is safe for livestock. Several studies on *Tithonia*, *Cassava*, and Gamal added to the ration mix did not affect the productivity and digestibility of ruminants if the dose was not excessive (Jamarun *et al*., 2020b).

### *Nutrient Digestibility*

The treatment of various forage sources and PKCC + TW concentrates gave a significantly different effect on the digestibility of dry matter, organic matter, and crude protein. ECDG that received *Cassava* leaf forage and PKC concentrate revealed higher digestibility than the goats that were given field grass, *Tithonia*, and Gamal. This means that *Cassava* leaves can play a role in increasing digestibility.

Whether or not the quality of a ration given to livestock can be seen from the percentage of DMD. The higher the DMD, the higher the opportunity for nutrients utilized by livestock for growth and production. Ja and Oloidi (2014) obtained lower DMD scores than this study, which was 70.98%. Isah *et al*. (2015) got the higher DMD which was 754%. The difference in DMD is due to the type and nutritional content of the rations given.

The average DMD value of the treatment ration increased with the provision of *Tithonia* forage, *Cassava* leaves, and PKC concentrate. In this case, this is due to the better nutritional content of the ration. The percentage of OMD in this study ranged from 69.43 to 77.25%. The treatment of various forages and PKC-based concentrates had a significant effect on OMD. Treatment C got the highest OMD (77.25%) while the lowest was treatment A (69.43%). The OMD value increased along with the rise of the DMD. Jamarun *et al.* (2018) reported that the pattern of OMD is related to DMD. Most of the dry matter content is digestible organic matter such as carbohydrates, proteins, and fats.

The range of crude protein digestibility of the treatment was 71.26-86.01%. Treatment C got the highest CPD (88.01%) while treatment A got the lowest CPD (71.26%). The chemical composition of feed ingredients dramatically affects the level of digestibility. The quality of the ration is proportional to the digestibility of crude protein. CPD is also associated with the consumption of crude protein. High crude protein consumption will result in high crude protein digestibility. Putri *et al*. (2021) stated that crude protein digestibility is influenced by microbial protein synthesis. Microbial protein synthesis will increase along with the rise in ration protein (Pazla *et al*., 2018a).

The treatment of giving various forages and PKC+TW concentrates had a significant effect on the increase in CPD. This means that the application of *Tithonia*, *Cassava*, and Gamal up to 50% could maintain the CPD. Crude protein digestibility is highly dependent on the performance of proteolytic bacteria. Proteolytic bacteria are bacteria that produce extracellular protease enzymes that will break down protein in feed. The significant difference between treatments was due to different proportions of proteolytic bacteria in each treatment. The CPD in this study was higher than (Supriyati and Haryanto, 2011), who obtained a CPD of the combination of elephantgrass and palm kernel cake of 73.027-75.99%. The difference is due to the feed ingredients which are concentrate and forage.

## Conclusion

Replacement of field grass with various forage sources and replacement of tofu waste with concentrate- based palm kernel cake could increase feed consumption and digestibility, as well as increase the protein, lactose, and fat of milk.

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## Author’s Contributions

**Arief:** Designed the research plan and organized and supervised the study.

**Roni Pazla:** Conducted the research, analyzed data, and contributed to the writing of the manuscript.

## Ethics

This article is original and has never been published before. The author has also confirmed to all authors involved in this study to read and agree to the contents of this article and that there are no ethical issues involved.

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