Milk lactose, specific gravity and mineral of Etawa dairy goat fed with palm kernel cake based concentrate, tithonia (*Tithonia diversifolia*), sweet potato leaves (*Ipomoea batatas* L) and gamal (*Gliricidia sepium*)

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Abstract. This study aims to evaluate the milk lactose, specific gravity, and mineral of Etawa Crossbred Dairy Goat (ECDG) fed with palm kernel cake based concentrate (PKCC), tithonia (*Tithonia diversifolia*), sweet potato leaves, (*Ipomoea batatas* L.), and Gamal (*Gliricidia sepium*) as a source of roughage. The design of the experiment used was a completely randomized design (CRD) with four treatment rations and four replications. Treatment formulations are as follow: A). 100% basal ration (BR); B). 50% BR + 50% Concentrate Based Palm Kernel Cake (CPKC) + tithonia; C). 50% BR + % CPKCC + sweet potato leaves; D). 50% BR + 50% CPKC + Gamal (*Gliricidia sepium*). The ratio of concentrate and roughage is 50:50. The concentrate ratio consists of 30% palm kernel cake, 40% tofu waste, 20% rice bran, 9% corn, and 1% mineral. The parameters were milk lactose, specific gravity, and mineral of milk. Data were analysed by Analysis of Varian (ANOVA) and DMRT (Duncans Multiple Range Test) according to Steel and Torrie (2002). The results showed that the treatment had no significant effect (P> 0.05) on lactose, specific gravity, and mineral of milk. From this study, it can be concluded that the use of PKC, titionia, sweet potato, and gamal can replace basal ration without affecting the quality of milk (lactose, specific gravity and mineral).

1. Introduction
One of the factors that affect livestock productivity is feed. In the long term, it is necessary to look for alternative feed ingredients with abundant availability and quality to reduce dependence on imported feed ingredients which are expensive. One of the feed ingredients that meet the requirements above is a by-product of palm oil industry, namely palm kernel cake (PKC).

Nutrient content of palm kernel cake is dry matter (DM) 91.83%, organic matter (OM) 91.41%, crude protein (CP) 12.36%, crude fiber (CF) 26.68% and total digestible nutrient (TDN) 65.40% [1]. Also, adding by [2] that Palm kernel cake is a by-product of the palm oil industry which potentially can be used as concentrate feed for Etawa Crossbred Dairy Goat. The use of concentrates containing palm kernel cake in ECDG showed good milk quality as reported by [3], which received milk protein 4.39%, milk fat 8.23%, and Solid Non-Fat (SNF) 9.01%.

In addition to the by-products of the palm oil industry, as a substitute for forage in goats, "tithonia" (*Tithonia diversifolia*) can be used, which grows widely in vacant land in West Sumatra. Tithonia grows as a shrub, especially on uncultivated vacant land. At the same time, sweet potato leaves and Gamal are nutritious foraged ingredients that can be used as a source of forage for livestock [4]. Furthermore, added...
by [5] that based concentrates PKC with tithonia, sweet potato leaves, and Gamal for forage sources can be used as alternative feed ingredients to maintain the production and quality of goat milk.

The tithonia plant is a shrub plant that is highly favored by ECDG [6]. The protein content of tithonia is quite high at 22.98% [7]. The use of tithonia as a source of forage in ECDG can increase milk production and milk quality [2]; [3]. Apart from the tithonia plant, sweet potato leaves are also highly potential to be used as forage. [8] stated that sweet potato leaves contain roughly 24-29% crude protein. Also, [9] states that sweet potato leaves contain high crude protein, 26-35%, with good mineral content and vitamins A, B2, C, and E. The chemical composition of sweet potato leaves based on dry ingredients is 88.46% DM, 25.51% CP, 14.22% Ash, 24.29% CF, 15% extract ether, ingredients extract without nitrogen is 34.70%, calcium (Ca) 0.79% and Phosphorus (P) 0.38% [10].

Etawa Crossbred Dairy Goat (ECDG) is an indigenous livestock goat of Indonesia, especially for dairy goats. ECDG comes from the crossing of etawa goats from India with local Indonesian goats. Etawa dairy goat is one alternative livestock for dairy cattle diversification, aside from dairy cows. Various studies indicate that goat milk has quite the popularity and has the advantage of being easier to digest compared to cow's milk because of its smaller size of fat and in a more homogeneous form. Further explained that the use of non-conventional feed with probiotic supplementation is expected to achieve livestock needs in terms of protein and energy to support the productivity of dairy goats [1]. Based on the description above, the research was conducted to study the effect of the use of rations containing palm kernel cake, tithonia, sweet potato leaves, and Gamal (Gliricidia sepium) as a source of roughage on the lactose, specific gravity, and mineral of milk.

2. Material and methods
This research is a biological test on palm kernel cake-based rations with various local forage sources (Tithonia, sweet potato leaves and gamal) which are preferred by goats. The livestock used were Etawa Crossbred dairy goats (ECDG) which were lactating. The study used a completely randomized design (CRD) with four treatments and four replications. The treatments are as follow:

1. Treatment A). 100% Basal Ration (control)
2. Treatment B). 50% Basal Ration + 50% Concentrate Ration PKC (CRPKC) + Tithonia
3. Treatment C). 50% Basal Ration + 50% (CRPKC) + Sweet Potato Leaf
4. Treatment D). 50% Basal Ration + 50% (CRPKC) + Gamal

Concentrate Ration Palm Kernel Cake (CRPKC) consists of 30% PKC, 40% tofu waste, 20 rice bran, 9% corn, and 1% minerals [11]. The ratio of forage and ration concentration is 50%: 50%. The rations are prepared based on dry matter 3% body weight with protein, and total digestible nutrient (TDN) rations are 10 – 12% and 65 – 70%.

2.1. Parameters
Parameters measured in this study were milk lactose, specific gravity, and mineral content. Lactose and specific gravity of milk were measured using a Lactodensimeter Su.Fat.Ger.01 (Gerber Instrument: Switzerland) while milk minerals were measured by precipitation of calcium oxalate and ammonium molybdate.

2.2. Statistic analysis
The data obtained were analyzed using analysis of variance, while differences between treatments were tested using the Duncant Multiple Range Test (DMRT) according to [12].

3. Results and discussion

3.1. Milk Lactose
Lactose is a milk carbohydrate consisting of glucose and galactose [13]. Milk lactose levels are associated with milk production, where elevated lactose levels indicate an increase in milk production because lactose plays a role in osmoregulation in the mammary gland. The average lactose content of
Etawa hybrid goat milk by giving concentrate rations based on palm kernel cake and giving tithonia, sweet potato leaves, and gamal as a source of forage can be seen in the following Table.

**Table 1.** Milk lactose etawa crosbred dairy goat fed palm kernel cake and tithonia, sweet potato leave and gamal as a source of roughage.

| Treatment | Replications | Average |
|-----------|--------------|---------|
| A         | 1            | 5.60    |
|           | 2            | 5.32    |
|           | 3            | 4.98    |
|           | 4            | 5.34    |
| B         | 1            | 4.89    |
|           | 2            | 5.34    |
|           | 3            | 5.22    |
|           | 4            | 5.12    |
| C         | 1            | 5.21    |
|           | 2            | 5.12    |
|           | 3            | 5.23    |
|           | 4            | 4.89    |
| D         | 1            | 5.32    |
|           | 2            | 4.89    |
|           | 3            | 5.23    |
|           | 4            | 5.13    |

The table above shows that the lactose content of Etawa Crenbred Dairy Goat milk-fed concentrate rations based on palm kernel cake and tithonia, sweet potato leaves, and gamal forage. In this case, the highest was in treatment A, namely 5.31%, and the lowest was in treatment C, with 5.11%. The analysis of variance showed that the use of concentrate rations based on PKC and tithonia, sweet potato leaves, and gamal as a forage source gave no significant difference (P>0.05) on the lactose content of milk. The lactose content of milk obtained from this study was still included in the reasonably good category in accordance with the opinion of [14], stating that the lactose content of milk ECDG ranged from 4.64 to 5.46%.

Milk lactose is a component of milk that mostly consists of carbohydrate components, including glucose and galactose. [15] stated that when the ratio energy in carbohydrates and fats is insufficient, some of the amino acids will be converted into glucose through gluconeogenesis. Gluconeogenesis is the process of forming glucose from nutrients other than carbohydrates, such as protein. Furthermore, [16] explained that milk lactose comes from easily digestible carbohydrates, namely Non-N Extract Material contained in the feed, which is then fermented in the rumen into volatile fatty acids, namely propionic acid. The propionic acid then undergoes a gluconeogenesis process in the liver to form glucose which will be carried by the blood to the secretory cells of the udder gland to be used as raw material for the synthesis of milk lactose. Also, added by [17], the gluconeogenesis process will change amino acids absorbed in the small intestine into glucose in the liver. Thereby, it increases blood glucose which will be carried to the secretory cells of the udder gland to be used as raw material for the synthesis of milk lactose. Milk lactose is formed from glucose derived from carbohydrates, where propionic acid is converted to glucose in the liver.

Besides giving concentrate as a protein supply for livestock, this study also used tithonia, sweet potato leaves, and gamal as a source of forage. The consumption of forage given in the study is 10% of the bodyweight of the livestock. Tithonia has a relatively high nutritional content, especially crude protein, reaching 19.4% [18], [9] stated that sweet potato leaves also have a high crude protein, which is 26-35%. Thus, by providing adequate forage according to livestock needs, it will increase the availability of amino acids in the blood, which will be converted into simple sugars, namely glucose. It will be utilized to synthesize lactose in milk, and so the case with gamal containing high enough protein.

The lactose content of milk from the results of this study was higher than the results of the study by [19], which provides additional cassava leaves where the lactose content of milk obtained ranges from 3.70% - 4.12%. However, the results of this study are almost the same as those of [20] with milk lactose levels ranging from 3.53% - 5.48% and [2] who got milk lactose content ranging from 4.03% - 4.16%. The use of a combination concentrate-based palm kernel cake and *Tithonia diversifolia*, corn waste, and gamal in the treatment had no significant effect (P> 0.05) on the lactose content of ECDG goat milk. Milk lactose levels obtained from this study ranged from %. This result is lower than that of [21], which is 5.5 %, and [14] is 4.64 – 5. 46 %. The levels of lactose of A, B, C, and D, are the same. It is because the influence of protein feed in A, B, C, and D is similar. Amino acids absorbed in the intestine are converted into glucose in the liver through gluconeogenesis, thereby increasing glucose levels in the blood and then increasing milk lactose levels. Similarly, it is stated that glucose is the primary precursor of milk lactose formation [22].
The graph of the lactose content of goat's milk-fed with palm kernel cake and tithonia, sweet potato leaves, and gamal as a source of forage can be seen in the following Figure 1.

![Figure 1. Milk lactose of ECDG Fed PKC and tithonia, sweet potato leaves and gamal.](image)

3.2. Specific gravity of milk
The average specific gravity of Etawa Crossbred Dairy Goat milk with concentrate rations based on palm kernel cake and tithonia, sweet potato leaves, and gamal as forage sources can be seen in the following Table.

| Treatment | Replications | Average |
|-----------|--------------|---------|
| A         | 1.0280       | 1.0283  |
|           | 1.0284       |         |
|           | 1.0284       |         |
|           | 1.0284       |         |
| B         | 1.0284       | 1.0282  |
|           | 1.0280       |         |
|           | 1.0281       |         |
|           | 1.0281       |         |
| C         | 1.0281       | 1.0281  |
|           | 1.0281       |         |
|           | 1.0280       |         |
|           | 1.0280       |         |
| D         | 1.0280       | 1.0280  |
|           | 1.0280       |         |
|           | 1.0280       |         |
|           | 1.0280       |         |

From Table 2, it can be seen that the highest specific gravity of Etawa Crossbred Dairy goat's milk was found in treatment A, which was 1.0283%, and the lowest was found in treatment D, which was 1.0280%. The results of the analysis of variance showed that the use of CRPKC and tithonia, sweet potato leaves, and gamal as a source of forage gave no significant effect (P>0.05) on the specific gravity of Etawa Crossbred Dairy Goat milk. The lactose content of milk obtained in this study was still included in the reasonably good category based on the Indonesian National Standard (SNI) 3141.1.2011; the specific gravity of normal milk was 1.028. Added by [23], goat's milk's specific gravity is higher than that of cow's milk in the range 1.0231 – 1.0398.

The dry matter content of milk depends on the nutrients consumed by livestock which are then used as precursors to form dry matter or milk solids, which will affect the specific gravity of milk. Similarly, [24] stated that the specific gravity of milk is influenced by the dry matter content of the feed so that an increase in the dry matter of the feed will increase the specific gravity of milk. According to [25], the dry matter content of milk depends on the content of food substances consumed by livestock which are then used as precursors for the formation of dry milk matter. Therefore, if feed requirements are met, the dry matter content of milk increases. The dry matter ingredients of milk consist of fat globules, lactose, protein, and mineral. Milk fat content also affects the specific gravity of milk because the specific gravity of fat is lighter than water and other solids in milk [26]. The specific gravity of milk is inversely proportional to the fat content, where if the milk fat content is high, then the milk-specific gravity will be low. Moreover, if the milk fat content is low, then the milk density will increase so that there is an inverse relationship between the fat content and the specific gravity of milk. Milk mixed with water will reduce the specific gravity of milk. According to the Indonesian National Standard (SNI)
3141.1.2011, the specific gravity of normal milk is 1.028. Also, [23] added that the specific gravity of goat's milk is higher than that of cow's milk in the range of 1.0231 - 1.0398.

The above study results indicate that the specific gravity of milk is higher than some of the references above. This indicates that the high dry matter of the treatment ratio used causes the high specific gravity of the milk produced. The density of milk from this study is almost the same as the results of [27] by giving cassava leaves up to 1.36 kg/head/day (20% of forage consumption) in the form of silage with the density of milk obtained ranging from 1.0294 - 1.030. The graph of the specific gravity of goat's milk-fed with palm kernel cake-based tithonia, sweet potato leaves, and gamal as a source of forage can be seen in the following Figure 2.

![Specific Gravity of Milk](image)

**Figure 2.** Specific gravity of milk of ECDG Fed PKC and tithonia, sweet potato leaves and gamal.

### 3.3. Mineral of milk (Ca dan P)

The average of Ca and P content of Etawa Crossbreed Dairy goat milk with concentrate rations based on palm kernel cake (PKC) and tithonia, sweet potato leaves, and gamal as forage sources can be seen in the following Table.

| Treatment | Mineral of Milk (%) |
|-----------|---------------------|
|           | Ca  | P  |
| A         | 2.70| 0.57|
| B         | 2.73| 0.62|
| C         | 2.65| 0.59|
| D         | 2.87| 0.61|
| Average   | 2.74| 0.59|

The Ca and P content of the research milk was relatively high, namely 2.74% and 0.59%, due to the feed given having a reasonably good nutritional content. This is in accordance with the statement of [28] that the content of the feed given strongly influences the content of Ca and P in milk. The high or low calcium content of milk is caused by the protein content of the feed, where the lower the protein in the feed will cause the inhibition of calcium absorption in livestock [28]. While the phosphorus content in milk is also influenced by the phosphorus content of the feed given [28], [29] added that the primary source of phosphorus for livestock is feed that has undergone a digestion and absorption process.

Goat milk is a good source of Ca and nutrients. In addition, goat's milk is also suitable for individuals allergic to cow's milk because some proteins in cow's milk that cause allergies are not found in goat's milk. Moreover, in goat's milk, it also found some anti-inflammatory substances such as oligosaccharides [30]. The content of Ca and P in this study is still relatively high compared to the standard Ca and P in fresh milk according to [31], which are 0.143% and 0.06%.
The graph of goat's milk-fed mineral with palm kernel cake-based tithonia, sweet potato leaves, and gamal as a source of forage can be seen in Figure 3.

Figure 3. Mineral of milk (Ca dan P) of ECDG Fed PKC and tithonia, sweet potato leaves and gamal.

4. Conclusion
Concentrate ration based on Palm Kernel Cake and tithonia, sweet potato leaves, and gamal can replace 50% basal ration without affecting milk quality, namely lactose, specific gravity, and mineral (Ca and P).

References
[1] Arief 2013 Disertasi Program Pascasarjana Universitas Andalas.
[2] Arief, N Jamaran, B Satria 2018 International Journal of Dairy Science 13 15 – 21.
[3] Pazla R 2018 Disertasi Program Pascasarjana Universitas Andalas.
[4] Arief, N Jamaran, B Satria 2019 Paten Sederhana (Granted) SID201907138.
[5] Arief, Rusdimansya, S Sowmen, R Pazla, Rizqan 2020 Biodiversitas 21 4004 – 4009.
[6] Rizqan 2018 Tesis Program Pascasarjana Fakultas Peternakan Universitas Andalas.
[7] Jamarun, N, M Zein, Arief, R. Pazla 2018 Pak. J. Nutr 17 39-45.
[8] Nguyen TT, B Ogle 2004 Department of Animal Nutrition and Management.
[9] Adewolu MA 2008 Pak J Nutr 7 444-449.
[10] Nursiam I 2008 Skripsi Fakultas Peternakan Institut Pertanian Bogor.
[11] Arief, Rusdimansyah, S Sowmen, R Pazla 2019a Pakistan Journal of Nutrition 18 733 – 738.
[12] Steel RGD, JH Torrie 1991 Prinsip dan Prosedur Statistik Suatu Pendekatan Biometrik (Jakarta: PT. Gramedia Pustaka Utama).
[13] Ensminger ME 2002 Sheep and Goat (Animal Agriculture Series) 6thEd (US: Interstate Publishers, Inc).
[14] Subhagiana IW 1998 Tesis Program Pascasarjana Institut Pertanian.
[15] Yusuf R 2014 Bioma 3 1-15.
[16] Yusuf R 2010 Jurnal Teknologi Pertanian 6 1-6.
[17] Soebarinioto, S Chuzaeini, Mashudi 1991. Ilmu Gizi Ruminansia (Malang: Universitas Brawijaya).
[18] Adrizal, Montesqrit 2013 Laporan Penelitian Rapid Tahun pertama Universitas Andalas.
[19] Jupamatta A, U Kanto, C Tirawattanananich 2011 Journal Animal Science 24 517-524.
[20] Siska I 2014 Tesis Program Pascasarjana Fakultas Peternakan Universitas Andalas.
[21] Adriani 2003 Dissertasi Program Pascasarjana Institut Pertanian Bogor.
[22] Schmidt GH, LD Van Vleeck, MF Hutjens 1988 Principles of Dairy Science 2ndEd. (New Jersey: Englewood Cliffs).
[23] Park YW, M Ju arez, M Ramos, GFW Haenlein 2007 Small Ruminant Research 68 88-113.
[24] Zurriyati Y, Noor RR, Maheswari RRA 2011 Jurnal Ilmu Ternak dan Veteriner 16 61 – 70.
[25] Wibowo PA, TYAstuti, P Soediarto 2013 Jurnal Ilmiah Peternakan 1 214-221.
[26] Utari FD, Prasetiyono BWH, Mukhtadi A 2012 Animal Agricultural jurnal 1 427 – 441.
[27] Sofrianti N 2012 Skripsi Fakultas Peternakan, Institut Pertanian Bogor.
[28] Oka B, Wijaya M, Kadirman 2017 Jurnal Pendidikan Teknologi Pertanian 3 195-202.
[29] Nurlena 2005 Tesis Program Pascasarjana Universitas Diponegoro.
[30] Mateljan G 2008 Milk Goat (USA: The GM Foundation).
[31] Depkes RI 2005 Kandungan Gizi Susu Sapi Per100g Direktorat Gizi Departemen Kesehatan Republik Indonesia.

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