Effects of substituting Leucaena (*Leucaena leucocephala*) as roughage source on digestibility, blood metabolites and ruminal fermentation in growing goat

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**Abstract.** This study aimed to assess the effects of three levels of inclusion (0, 50, and 100%) of Leucaena (*Leucaena leucocephala*) as roughage sources on growing goats. Feed nutrient digestibility, blood urea nitrogen (BUN), blood glucose (BG), and ammonia nitrogen concentration (NH$_3$-N) of goats were measured. The results showed that the control and the 50% Leucaena in roughage groups had higher DM, OM, NDF, and ADF digestibility than the 100% Leucaena group. The digestibility of CP in goats fed with 50 and 100% of Leucaena in roughage was significantly (P<0.05) higher than goats in the control group. The values of pH, NH$_3$-N, and BG of all treatments were not significantly different. The ruminal NH$_3$-N concentration did not change with different proportions of Leucaena leaf, ranged between 24.98-26.52 mg/dL. The BUN and BG concentrations in this trial were within the physiological range of goats. Results of this study concluded that substitution of grass by Leucaena up to 50% enhanced DM, CP and fiber digestibility but total substitution reduced nutrient digestibility (except CP). However, substitution at both levels did not affect blood metabolites and ruminal fermentation of growing goat.

1. **Introduction**

Goats play a significant role in the livelihoods of the rural populace in most developing countries. Apart from serving as a vital protein source, it also provides income for meeting urgent household needs. The scarcity of animal feed during the dry season is a common problem limiting animal production in tropical areas. In the dry season, the forage biomass and quality available for animal feed are both low [1]. However, some tropical plants, such as leguminous trees, could be used as feed and research has reported that ruminants can supplement their diet by browsing leguminous plants [2]. For example, the Leucaena (*Leucaena leucocephala*) is mostly found in the tropics and was considered a high-quality forage because of its high protein level with a good amino acid profile. The usage of the leaf in goat feed shows a good result in growth rate, dry matter (DM) digestibility, DM intake for Leucaena and DM intake, nutrient digestibility, and weight gain [3]. However, the problem with the forage is the content of anti-nutritive as mimosine, factors that may exhibit health impairment in ruminants if consumed excessively [3]. The compound is mimosine in Leucaena's effect on the nutritive value of forages and animals fed them. Ingested feed components have been shown to have measurable effects on the blood constituents and ruminal fermentation. The effects of dietary
treatment on the performance and physical functions of the animal can be monitored through blood metabolite and ruminal fermentation examination. Blood and ruminal fermentation examinations also provide an opportunity to assess the health and nutritional status of an organism [4]. Leucaena has the potential for both positive and negative impact, thus it is important to study its effect on digestion and health status of animals fed this plant material in the diet [1]. Hence, the objective of this study was to assess digestibility, ruminal fermentation and blood metabolites in goats fed different levels of Leucaena leaf in a grass-based roughage source.

2. Methology

2.1 Animals, diets and experimental design

Fifteen 50% Thai native and 50% Anglo-Nubian crossbred male goats aged 4 to 6 months old weighed 17.20 ± 2.5 kgBW were randomly assigned into three treatments with five replicates. They were fed 2% of BW concentrate meal plus various levels of Leucaena substitution according to three treatments of a different substitution as grass only (control), 50% grass plus 50% of Leucaena and Leucaena only. The animals were balanced across the three treatments with bodyweight under a completely randomized design (CRD). Fifteen pens were used to house the animals individually. They were dewormed with ivomectin® (1.0% w/v sterile solution of ivermectin) and injected AD3E vitamins before the experiment started. The goats were daily fed (as fed basis) of concentrate meal which un pelleted form was prepared from cornmeal, soybean meal, rice bran, molasses, di-calcium, and salts according to the formulations (Table 1). Roughage ad libitum designed with the dietary treatments, fresh signal grass (Brachiaria humidicola) was used as the roughage source and daily provided with allowing not more than 10 % refusals.

| Feedstuffs       | Portion (kg) |
|------------------|-------------|
| Soybean meal     | 41          |
| Rice bran        | 25          |
| Ground corn      | 30          |
| Molasses         | 3           |
| Di-calcium       | 0.5         |
| Salts            | 0.5         |
| **Total**        | **100**     |

|                           | Calculation protein | Protein ingested (g/kg) |
|---------------------------|---------------------|-------------------------|
|                           | 16                  | 52.44-55.2              |

2.2 Data collection, sampling procedures

The goats were housed individually in metabolism crates for in vivo digestibility that consisted of 21 days divided into two periods. In the first 14 days for the adaptation period and the last 7 for sample collection (diets and feces) (days 15 to 21). Feed consumption was daily recorded by weighing feeds offered and orts to calculate feed intake. The samples of fecal from each goat were bulked, and then oven-dried at 65 °C for 72 hr, before analysis for chemical composition. The samples of feed and feces were dried and ground to pass through a 1 mm diameter sieve. The samples were analyzed for DM, CP, EE, and ash [5], NDF, ADF, and ADL were analyzed [6]. The digestibility coefficient of nutrients has used the equation:

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\text{Digestibility coefficient of the nutrient} = \frac{\text{Intake nutrient (g/d)} - \text{Faecal nutrient (g/d)}}{\text{Intake nutrient (g/d)}}
\]

The ruminal fluid samples were once collected at 0 and 4 hr post-feeding. Approximately 200 mL of rumen fluid was taken from the middle part of the rumen. The samples were immediately measured
for pH and ammonia-nitrogen (NH3-N) [7]. Blood samples of about 10 mL were drawn from the jugular vein and filled heparinized tubes at the same time as rumen fluid sampling. The samples were detected of blood urea nitrogen (BUN) and blood glucose (BG) contents [8].

2.3 Statistical analysis
The treatment means were compared by Duncan's New Multiple Range Test. All statistical analysis was performed using the SAS (1996) procedure. The results were shown as mean ± standard error of the mean (SEM) and statistical significance was based on P<0.05.

3. Results and Discussion
3.1 Chemical composition
The nutritive values of the experimental diets are shown in Table 2, which showed that the level of CP was increased with increasing levels of the grass been substituted with Leucaena leaf. Ruminants need a proper CP requirement from forage of 7% [9] but in this study, the signal grass used contained only 4.26% of CP and also high fiber, and are poorly digested by animals [10]. The CP content of the treatment diets was 16.56% and 21.23%, respectively, for the 50% and 100% Leucaena diet.

| Chemical composition | Level of Leucaena substitution (%) | Concentrate |
|----------------------|------------------------------------|-------------|
| DM                   | Control group 91.34                 | 91.75       | 92.16       | 91.98       |
|                      | 50 84.38                           | 83.795      | 83.21       | 85.62       |
|                      | 100 11.47                          | 16.56       | 21.23       | 22.29       |
| OM                   | 91.34                              | 91.75       | 92.16       | 91.98       |
| CP                   | 84.38                              | 83.795      | 83.21       | 85.62       |
| NDF                  | 11.47                              | 16.56       | 21.23       | 22.29       |
| ADF                  | 79.66                              | 65.3        | 50.94       | -           |
|                      | 47.74                              | 39.27       | 30.81       | -           |

Abbreviation: DM = dry matter, OM = organic matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber.

The CP content of diets that substituted L. leucacephala in roughage was higher than the requirement for ruminant maintenance. The feed of ruminant maintenance should be containing less than 8% of CP content could not provide the ammonia levels required by rumen microbe for optimum activity. The suggestion for supplemented such forage with appropriate nutrients to achieve a high level of animal production. [11].

3.2 Apparent digestibility
The digestion coefficients of DM, OM, NDF, and ADF were statistically different (P<0.05) among the treatments (Table 3). The result showed that the control and the 50% Leucaena groups had higher DM, OM, NDF, and ADF digestibility than 100% Leucaena. The low digestibility of the 100% Leucaena in the roughage may be due to increased fiber intake which depresses the digestibility of NDF [12]. While the digestibility of CP in goats that fed diets with 50 and 100% of Leucaena in roughage was significantly (P<0.05) higher than the goat in the control group, indicating that the CP in the Leucaena is the highly digestible true protein which may be resulting in to increase uptake of amino acids peptides or both by ruminal microbes [13, 14].
Table 3. Effect of supplemental Leucaena to roughage source on apparent digestibility of goats fed different diets.

| Parameters  | Levels of Leucaena substitution (%) | SEM | P-value |
|------------|------------------------------------|-----|---------|
|            | Control  | 50  | 100     |         |
| Apparent digestibility (%) |         |     |         |         |
| DM         | 83.35a   | 82.92a | 75.42b  | 4.51    | 0.03    |
| OM         | 85.55a   | 83.92a | 75.12b  | 4.56    | 0.02    |
| CP         | 74.82b   | 85.03a | 82.44a  | 5.33    | 0.03    |
| NDF        | 82.97b   | 79.34a | 64.42b  | 4.68    | 0.01    |
| ADF        | 85.01b   | 79.97b | 60.97b  | 5.52    | 0.01    |

Means within the same row with different superscripts differ (P<0.05), DM= dry matter, OM= organic matter, CP= crude protein, NDF= neutral detergent fiber, ADF= acid detergent fiber.

3.3 Ruminal pH, NH₃-N changes and blood metabolites

The values of pH, NH₃-N, and BG of all treatments were not significantly different among treatments (Table 4). The rumen pH is higher before morning feeding than 4 hrs after feeding because of the presence of highly fermentable carbohydrates [15]. The study showed that pH was unaffected by dietary treatments. Since the ruminal pH values were at an all-time above 6.0, the activity of cellulolytic bacteria should not be suppressed [16] as the pH of rumen fluid above 5.8 considered normal, while those between 5.5 and 5.8 may be suffering from subclinical acidosis [17]. Ruminal pH is partly regulated by NH₃-N in rumen fluids, the variation in pH may be explained by the urea entering the rumen and being hydrolyzed by microbial ureases into CO₂ and ammonia [18]. The ruminal NH₃-N concentration in this study was not changed by different proportions of Leucaena leaf averaged 24.98-26.52 mg/dL. The goats that fed the diet with different levels of Leucaena tended to decrease NH₃-N concentration in rumen fluid but did not significantly different as compared with the control group. The concentration of NH₃-N was higher than 5 mg% which is the appropriate level of NH₃-N for microbial protein synthesis in mixed culture in a closed system. However, an optimal level was 15 to 30 mg/dL to improve rumen ecology, digestibility, and intake. Also, NH₃-N concentration is related to protein content in the feed because many rumen micro-organisms required ammonia for the growth and synthesis of microbial protein [19]. The BUN concentration of goat after 4 hrs feeding was not significantly different among the diets and were in the normal physiological range for goat reported to be between 11.2-27.7 mg/dL [20]. In general, a lower concentration of BUN is an indication of low dietary protein levels or hepatic chronic disease. On the other hand, the increase of BUN could be the result of renal failure and body dehydration [12]. This study indicated that NH₃-N concentration in goat receiving diets 100% of the leaf was slightly higher than as compared with the control group may be as resulting in BUN concentration increased. The BUN concentration in this trial was higher probably as a result of the higher protein in diet and protein intake.

In the current study proportion of Leucaena inclusion in roughage sources on BG concentration at 0 and 4 hr post-feeding was not significantly different among treatments. BG concentration before morning feeding of the goats tended to lower than that taken 4 hr after feeding. However, the concentration in this trial was in the normal physiological range in the goat. According to reporting that a normal physiological range of BG in a goat was 50 to 75 mg/dL [21]. The variation in BG could be affected by stress and disease conditions. This investigation indicated that BG concentration goats offered Leucaena inclusion were in normal status. Its level is an indicator of carbohydrate metabolism in high-energy diets [22].
Table 4. Ruminal NH$_3$-N concentration and blood metabolites of goats fed different proportions of Leucaena substitution to roughage source.

| Parameters                  | Levels of Leucaena substitution (%) | SEM  | P-value |
|-----------------------------|-------------------------------------|------|---------|
|                             | Control 50 100                       |      |         |
| pH                          | 0 hr 6.63 6.68 6.66                 | 0.28 | 0.29    |
|                             | 4 hr 6.34 6.16 6.22                 | 0.23 | 0.91    |
| Ruminal NH$_3$-N concentration (mg/dL) | 0 hr 17.54 15.98 18.51 | 0.46 | 0.29    |
|                             | 4 hr 26.80 24.98 26.52 | 0.76 | 0.41    |
| Blood metabolites (mg/dL)   | BUN 0 hr 22.40 21.40 23.20          | 2.29 | 0.48    |
|                             | 4 hr 24.80 22.80 25.00 | 2.56 | 0.32    |
|                             | BG 0 hr 53.40 50.40 48.20          | 9.29 | 0.68    |
|                             | 4 hr 55.80 56.20 60.40 | 6.32 | 0.46    |

NH$_3$-N= ammonia nitrogen, BUN=blood urea nitrogen, BG=blood glucose and SEM=standard error of the mean

4. Conclusion
Results of this investigation concluded that provision of different levels of Leucaena leaf in diets up to 50% enhanced DM, CP and fiber digestibility but total substitution reduced nutrient digestibility except for CP digestibility. The blood metabolites and ruminal fermentation of the goat in this study were not changed by different proportions of Leucaena leaf in the diet. Further, long-term studies are required to gain more insights regarding the effect of Leucaena leaf on the performance of goats and feeding cost.

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