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# Research Article
# Body Weight Gain, Nutrients Degradability and Fermentation Rumen Characteristics of Boerka Goat Supplemented Green Concentrate Pellets (GCP) Based on *Indigofera zollingeriana*

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## Abstract

**Background and Objective:** *Indigofera zollingeriana* leguminous have been known widely to have a concentrate feed characteristic due to its high nutrient contents (crude protein, vitamin and some mineral) and its highly dry matter (DM) digestibility. This study aimed to identify the effects body weight gain, nutrients degradability, fermentation rumen characteristics and blood metabolite of Boerka goat supplemented green concentrate pellets (GCP)based on *Indigofera zollingeriana*. **Materials and Methods:** Twenty four male Boer x Kacang crossbreeds with age of approximately male phase to 6 months and average initial body weight (BW) 13±0.5 kg were used in feeding and degestion trials. The study was assigned according to randomized block design with four dietary treatments and six goats were allocated to one of four treatments in randomised block design. The animals feed was offered chopped fresh *Brachiaria humidicola* (*ad libitum*) and feed treatments were offered daily at 4.0% body weight (BW). **Results:** The digestibility increased in line with the increasing proportion of *I. zollingeriana* in the green concentrate pellets (GCP). The tannin content of GCP seemed to not significantly impacted on feed intake. The daily body weight gain and efficiency of feed utilization increased as the proportion of *I. zollingeriana* GCP increased. Increasing of the proportion *C. calotyhrsus* in GCP affected the concentration of ammonia ($NH_3$) and VFA of the rumen liquids of goat. **Conclusion:** Green concentrate pellets composing 90% *I. zollingeriana* gave the best results in term of daily body weight gain, feed intake, nutrient degradability, efficiency of feed utilization, rumen fermentation in Boerka goats.

Key words: Boerka goat, body weight gain, green concentrate pellets, *I. zollingeriana*, *C. calothyrsus*

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

The growth rate of goats and sheep meat production in Indonesia is about 3.8%$^{-1}$ year[1] which is quite low and need to increase to the maximum level. The quality and the supply of animal feeds is one of many factors that limit this production level. Maximum utilization of local feeds to increase the goat production is an alternative approach.

Some of forageshave potentials in providing high quality feeds[2-7]. *Indigofera zollingeriana* has been reported to be capable of adapting on drought, infertile land and on soil with high salinity[8]. The biomass production (strands, leaves and branches) is relatively high (21-31 t DM/ha/year)[8,9]. It contains relatively high crude protein content (25-29%)[8-10]. The utilization of *I. zollingeriana* as a feed supplement[11] or as a sole forage[12] have been shown to give good growth rate of goats. The provision of *I. zollingeriana* in the form of silage incompleted feed[13] or in the form of wafers[14] have resulted in good performances of goats.

Green concentrate pellets (GCP) composing of mixtures of *I. zollingeriana* and *C. calothyrsus* has been reported to have a good physical qualities and *in vitro* nutrient digestibility and ruminal fermentation[15]. Study research on feed green concentrate pellets based on combination *I. zollingeriana* and *C. calothyrsus* has been conducted to evaluate its effects on body weight gain, nutrients degradability, fermentation rumen characteristics and blood metabolite in goats.

## MATERIALS AND METHODS

**Diets, animals and experimental design:** The study was conducted at the Research Institute for Goat Production, Sungai Putih, North Sumatera Indonesia from July to December, 2016. The feeding trial was conducted following the guidelines of the Committee Indonesian Agency for Agricultural Research and Development on animal ethics. *Indigofera zollingeriana* and *Calliandra calothyrsus* were harvested at a 60 day-intervals and were cut at 1.0 m above ground level according to Tarigan *et al.*[9]. Green concentrate pellets were produced according to Tarigan *et al.*[15] that has been modified, in brief the procedures are as follows: (1) *I. zollingeriana* and *C. calothyrsus* were harvested and dried under sunlight for 1-2 days (approximately 20% DM), so that the green colors of the plant be maintained, (2) *I. zollingerina* and *C. calothyrsus* leaves were ground to pass a 1 mm screen using a Cyclotech Mill, (3) Ground *I. zollingeriana* and *C. calothyrsus* leaves were mixed with cassava meal, molasses, mineral mix and salt with the compositions as presented in Table 1. The mixing of all ingredients was taken for 10 min, (4) Water was added to the diet with ratio of 1:2, (5) Pellet were processed by using pellet machine with for capacity of 100 kg h$^{-1}$ at 5 mm diameter and (6) Pellets were then aërated for15 min and put into a sack before used. Samples of each diet treatment (100 g each) were analysed for its chemical compositions dry matter (DM), crude protein (CP), crude fat (CF), crude fiber, organic matter (OM), gross energy were analysed according to the standards methods of AOAC[16] for *Indigofera zollingeriana*, *Calliandra calothyrsus* and dietary treatments. Neutral detergent fiber (NDF) and Acid detergent fiber (ADF) were determined according to Van Soest *et al.*[17] with addition of α amylase, but without sodium sulphite and results were expressed with residual ash. Total content tannin (folinciocalteau) was analyzed according to Makkar[18].

Table 1: Composition of green concentrate pellets as feed supplements (% DM)

| Ingredients | R0 | R1 | R2 | R3 |
|---|---|---|---|---|
| *I. zollingeriana* meal | 0 | 90 | 60 | 45 |
| *C. Calothyrsus* meal | 0 | 0 | 30 | 45 |
| Palm kernel meal | 35 | 0 | 0 | 0 |
| Rice bran | 30 | 0 | 0 | 0 |
| Soybean meal | 15 | 0 | 0 | 0 |
| Corn meal | 10 | 0 | 0 | 0 |
| Cassava meal | 5 | 5 | 5 | 5 |
| Molasses | 3 | 3 | 3 | 3 |
| Premixes | 1 | 1 | 1 | 1 |
| Salt | 1 | 1 | 1 | 1 |
| Total | 100 | 100 | 100 | 100 |

Twenty four male Boer x Kacang crossbreeds with age of approximately 6 months and average initial body weight (BW) 13±0.5 kg were used in feeding and digestion trials. The experiment was assigned in a randomized block design with four dietary treatments and 6 replicates. Goats were randomly allocated to one of four the supplement diets. The experimental diets were as follows: (1) Control supplement (100% conventional feed and 0% green concentrate, R0), (2) Green concentrate (90% *I. zollingeriana*, 0% *C. calothyrsus*, 10% conventional feed ingredients, R1), (3) Green concentrate (60% *I. zollingeriana*, 30% *C. calothyrsus*, 10% conventional feed ingredients, R2) and (4) Green concentrate (45% *I. zollingeriana*, 45% *C. calothyrsus*, 10% conventional feed ingredients, R3). Concentrate control and green concentrate pellets (GCP) was fed daily to each animal at 4.0% of body weight NRC[19]. The experimental concentrates was offered twice (at 8 am and 2 pm) and chopped *Brachiaria humidicola* was fed *ad libitum* as the basal diet. All goats were kept in individual cage (1.2×0.8 m) and had free access to clean fresh water and the experimental diets at all times. The animals were allocated for a 21 days adaptation period and feeding and digestion trial proceeded for 90 days. The

animals were injected with ivomec (1.0 mL/25 kg b.wt.) to clear ectoparasites and endoparasites. Feed intake was recorded daily by weighing the offered diets and refusals from the previous day. Goats were weighed at the start of the experiment and body weights were measured at every week interval using weigher capacity of 50 kg with sensibility 0.1 kg.

**Sample collection and chemical analyses:** During the last 5 days, the animals were moved onto metabolism crates for total collection of feces and urine. Samples of feed offered, urine and faeces (100 g $kg^{-1}$ portion of daily production) were pooled for each animal for 5 day period and sub sampled for analyses. The DM of feed and faeces was determined by drying to a constant weight in a forced air oven at 60°C. The dried samples were ground to pass through a 1.0 mm screen and preserved for chemical analyses. Urine was collected in plastic containers containing 20 mL of concentrated sulphuric acids to prevent loss of N by volatilization. Samples were analyzed for dry matter (DM), organic matter (OM), crude protein (Kjeldahl N°6.25) according to the procedures of AOAC[16].

On the last day of each experimental period, ruminal contents were sampled at 4 h post morning feeding to determine the pH and concentration of fermentation end products. Rumen contents (100 mL) were collected once at each sampling time from the ventral sac using a stomach tube and the ruminal pH fluid was measured immediately using pH meter. The rumen fluid samples were collected and added 5 mL of 1 $MH_2SO_4$ to stop fermentation process of microbial activity and centrifuged at 15,000 rpm for 15 min. Approximately 20-30 mL of supernatant were collected and freezed at -20°C until analyzed for VFA concentration using gas chromatography method General Laboratory Procedure[20]. Rumen fluid samples were analysed for $NH_3$-N using the Conway method General Laboratory Procedure[20]. Blood samples (5 mL) was collected from a jugular vein of each animal and put into tubes containing 5.4 mg of EDTA and plasma was separated by centrifugation at 15,000 rpm for 10 min and stored at -20°C until analysed for plasma urea N and cholesterol using a colourimeter procedure kits diagnosis number kit 112191 and 101592.

**Statistical analysis:** Data on nutrient intake, digestibility, nitrogen balance, body weight, feed efficiency, blood metabolites and characteristics of rumen fermentation were analyzed using a block-randomized design with 4 experimental concentrates (R0, R1, R2, R3) and 6 goats were used within each treatment. The animals were blocked based on initial body weight. The mathematical model used was:

$$Y_{ijk} = \mu+\alpha_i+\beta_j+\varepsilon_{ijk}$$

where, $Y_{ijk}$ is the observation value of the-i treatment and the block-j, $\mu$ is the overall mean, $\alpha_i$ is the effect of dietary treatments-i, $\beta_j$ is the effect of block-j and $\varepsilon_{ijk}$ is the error of treatment-i and block-j. The different response to the treatments with probability ($p<0.05$).Treatment means were statistically compared by Duncan multiple range Test Steel and Torrie[21]. Statistical analyses were performed using the GLM procedure of SAS software version 9.1[22].

## RESULTS AND DISCUSSION

The nutrient compositions of the forages and green concentrate pellets (GCP) were shown in Table 2. The DM and OM of the GCP ranged from 93.87-95.62 and 82.96-85.96%, respectively. The CP content of GCP ranged from 19.18-21%, while gross energy content were similar among treatments ranging from 4.258-4.491 kcal $kg^{-1}$ DM. The NDF, ADF and crude fiber (CF) contents were relatively low ranging from 33.13-44.73, 17.29-27.70 and 8.49-10.04%, respectively. Total tannin content of *C. calothyrsus* was greater than that of *I. zollingeriana* and ranged from 0.85-4.66% (Table 2). Total tannin content on feed GCP increased as the proportion of *C. calothyrsus* in the GCP increased.

Table 2: Composition nutrients forage and green concentrate pellets (GCP)

| | Forage | | | Treatments | | | |
|---|---|---|---|---|---|---|---|
| Parameters | *B. humidicola* | *I. zollingeriana* | *C. calothyrsus* | R0 | R1 | R2 | R3 |
| DM (%) | 32.2 | 20.40 | 33.30 | 95.62 | 95.15 | 93.87 | 94.05 |
| OM (%) | 91.6 | 90.85 | 93.40 | 85.57 | 85.96 | 82.96 | 85.66 |
| CP (%) | 8.5 | 25.78 | 18.83 | 19.18 | 21.00 | 20.19 | 20.43 |
| NDF (%) | 70.9 | 35.64 | 47.70 | 42.18 | 44.73 | 38.82 | 33.13 |
| ADF (%) | 35.8 | 24.64 | 33.90 | 27.70 | 24.35 | 17.29 | 18.02 |
| Fat (%) | * | 3.38 | 1.81 | 5.35 | 3.30 | 3.06 | 3.09 |
| CF (%) | * | 14.25 | 11.70 | 10.04 | 8.49 | 8.95 | 9.35 |
| GE (kcal $kg^{-1}$) | 4586.0 | 4.262 | 4.676 | 4.258 | 4.491 | 4.445 | 4.340 |
| Total tannin (%) | * | 0.85 | 12.76 | 0.00 | 0.85 | 3.33 | 4.66 |

*Not analyzed, DM: Dry matter, OM: Organic matter, CP: Crude protein, NDF: Neutral detergent fibre, ADF: Acid detergent fibre, CF: Crude fibre, GE: Gross energy

Table 3: Feed intake and digestibility of Boerka goats supplemented with green concentrate pellets (GCP)

| | Treatments | | | |
|---|---|---|---|---|
| Parameters | R0 | R1 | R2 | R3 |
| **Intake (g/day DM)** | | | | |
| *Brachia riahumidicola* | 318.00±17 | 255.00±7 | 276.00±21 | 277.00±32 |
| Concentrate | 550.00 | 600.00 | 600.00 | 600.00 |
| **Nutrients intake (g/day/DM)** | | | | |
| DM | 817.87±16.52$^{b}$ | 874.17±47.19$^{a}$ | 876.67±18.62$^{a}$ | 884.17±33.18$^{a}$ |
| OM | 742.54±15.00$^{b}$ | 777.06±41.95$^{a}$ | 779.27±16.55$^{a}$ | 786.27±29.50$^{a}$ |
| CP | 131.28±2.65$^{a}$ | 151.45±8.81$^{b}$ | 146.91±3.12$^{b}$ | 149.67±5.62$^{b}$ |
| **Digestibility (% DM)** | | | | |
| DM | 77.76±2.79$^{a}$ | 77.60±3.12$^{a}$ | 76.11±3.34$^{a}$ | 71.09±4.29$^{b}$ |
| OM | 68.52±2.15$^{a}$ | 63.43±4.19$^{ba}$ | 58.38±5.96$^{b}$ | 52.45±6.02$^{c}$ |
| CP | 79.25±3.58$^{a}$ | 78.06±3.21$^{a}$ | 68.58±5.96$^{b}$ | 65.70±5.24$^{b}$ |

$^{a,b,c}$Means within a row without a common superscript letter differ significantly ($p<0.05$)

Nutrients intake and digestibility by the Boerka goat is shown in Table 3. DM, OM and CP intakes by goat fed on GCP were greater ($p<0.05$) compared to the control (R0). Although statistically not different ($p>0.05$), numerically DM, OM and CP intakes were greater in goats offered GCP of higher *I. zollingeriana* proportions. The DM intake levels obtained in this study ranged from 3.8-4% BW. The declining ratio *I. zollingeriana*: *C. calothyrsus* was followed by an increase in the total tannin content in GCP (Table 2). A positive relationship between the CP and tannin content with nutrients intake, as well as the negative correlation between protein and the NDF contents with feed intake was reported by Alonso-Diaz *et al.*[23] and Olafadehan *et al.*[7]. The tannin content of GCP seemed to not significantly impacted on DM, OM and CP intake. Olafadehan *et al.*[7] evaluated variations of the ratio of *ficus polita* containing tannin with feed concentrates fed Sokoto goats and did not find differences in feed intakes. The level of DM, OM and CP intakes in this study ranged from 884.17-876.67, 77.06-786.27, 146.91-151.45 g/day, respectively. These levels of DM, OM and CP consumption were relatively high compared to the results of Dianingtyas *et al.*[14] reporting that DM, OM and CP intakes were 770.72-792.77, 709.19-717.76 and 110.89-113.82 g/day, respectively in Ettawa goats given supplement feed of waffered *I. zollingeriana*, *C. calothyrsus* and *L. leucocephala*.

The digestibilities of DM, OM and CP were not significantly ($p>0.05$) different among RO, R1 and R2, but they were significantly higher ($p<0.05$) compared to R3. Thus digestibilities of DM, OM and CP significantly declined ($p<0.05$) as the proportion of *C. callothyrsus* (45%) in the green concentrate pellets (GCP) increased. The digestibility of OM by goats fed treatment R1 and R2 were significantly higher ($p<0.05$) compared to treatment R3. This could be related to the higher content of CP in those two treatments (20.19-21.00%). The digestibility increased in line with the increasing proportion of *I. zollingeriana* in the green concentrate pellets (GCP). The digestibility of feed is influenced by the nutrient compositions, feed processing, the level of feed intake and the animals[24].

The decline in the ratio of *I. zollingeriana*: *C. calothyrsus* in the GCP resulted in the increase of tannin content in GCP (Table 2). The tannin may have protection activity on protein degradation by microbes in rumen. An increase in the tannin content at certain level did not disclose negative impact on *in vitro* digestibility GCP Tarigan *et al.*[15]. The digestibilites of DM, OM and CP in goats fed R1,were 77.60, 63.43 and 78.06%, respectively. These figures were relatively in proportion to the study results of Dianingtyas *et al.*[14], found that the digestibilities of DM, OM and CP were 80.78, 75.36 and 66.30%, respectively in Ettawa goats fed wafers of *I. zollingeriana* based on forage:concentrates ratio of 35:65. However, those figures were higher compared to the results of Khy *et al.*[25] found that the digestibility of DM (70.21%) in water buffaloes fed *L. leucocephala* pellets (LLP) at 450 g/day. The relatively higher digestibility by goats in this study could possibly due to the higher total CP intake. The higher content of CP and a low level of fiber may have risen the digestibility of feed[26,15].

The nitrogen balance in Boerka goats supplemented with (GCP) is shown in Table 4. The N intake of goats in treatment R1 was significantly higher ($p<0.05$) compared to treatment R0, but was not different ($p>0.05$) to treatment R2 and R3. Increased proportion of *I. zollingeriana* in the GCP did not significantly ($p>0.05$) effect N intake, but they were higher ($p<0.05$) compared to treatment R0. The N intake was highest in goats fed GCP in treatment R1. The N balance (absorbed and retained) were positive in all treatments and the N balance was highest ($p<0.05$) in goats fed treatment R1 compared to other groups. The ratio of N absorbed to N intake was highest ($p<0.05$) in goats fed R1, but it was not different ($p>0.05$) to the R0. The ratio of N Retained to N intake was

Table 4: Nitrogen balance in Boerka goats supplemented with green concentrate pellet (GCP)

| | Treatments | | | |
|---|---|---|---|---|
| Parameters | R0 | R1 | R2 | R3 |
| N intake (g/day) | 20.98±0.4[b] | 24.25±1.2[a] | 23.52±0.5[a] | 23.93±0.8[a] |
| N fecal | 2.68±0.3[c] | 2.90±0.3[c] | 3.58±1.9[b] | 4.43±0.5[a] |
| N urinary | 3.01±0.5[b] | 3.81±0.5[a] | 3.80±0.5[a] | 3.83±0.4[a] |
| N absorption | 18.31±0.4[c] | 21.31±1.4[a] | 19.91±0.4[b] | 19.51±[b] |
| N retention | 15.29±0.4[b] | 17.54±1.1[a] | 16.14±0.5[b] | 15.67±1.1[b] |
| **N intake (%)** | | | | |
| N fecal | 12.9[a] | 12.0[a] | 15.3[b] | 19.1[c] |
| N urinary | 14.4[a] | 15.7[a] | 16.0[b] | 16.0[b] |
| N absorption | 87.1[a] | 88.0[a] | 84.7[b] | 80.9[c] |
| N retention | 72.7[a] | 72.3[a] | 68.6[b] | 64.9[c] |
| **N absorption (%)** | | | | |
| N retention | 83.5[a] | 82.2[a] | 81.0[b] | 80.2[b] |

[a,b,c]Means within a row without a common superscript letter differ significantly (p<0.05)

Table 5: Body weight, feed efficiency and blood metabolites of Boerka goats supplemented with green concentrate pellet (GCP)

| | Treatments | | | |
|---|---|---|---|---|
| Parameters | R0 | R1 | R2 | R3 |
| Initial body weight (kg) | 13.50±0.36 | 13.17±0.23 | 13.00±0.24 | 13.17±0.23 |
| Final body weight (kg) | 22.80±0.65 | 22.43±0.76 | 21.20±0.75 | 21.40±1.0 |
| Total body weight gain (kg) | 9.00±0.54[a] | 9.27±0.58[a] | 8.00±0.83[b] | 8.00±0.93[b] |
| Average daily gain (g/day) | 103.71±6.38[a] | 102.96±6.79[a] | 88.89±8.89[b] | 88.52±10.24[b] |
| Feed efficiency | 0.13±0.01[a] | 0.12±0.01[a] | 0.10±0.01[b] | 0.10±0.01[b] |
| Blood urea nitrogen (mg $dL^{-1}$) | 57.48±0.15 | 58.98±0.36 | 60.08±0.43 | 56.73±0.34 |
| Blood cholesterol (mg $dL^{-1}$) | 116.12±4.37[a] | 45.57±3.15[b] | 39.10±3.63[b] | 40.62±4.18[b] |

[a,b,c]Means within a row without a common superscript letter differ significantly (p<0.05)

highest (p<0.05) in goats fed control supplements (R0), but it was not different (p>0.05) to that of goats fed R1. Increase in the proportion of *I. zollingeriana* in GCP has increased the N intake. The level of N intakes in the GCP groups were significantly higher (p<0.05) compared to the control treatment (R0). This may relate to the high intake and digestibility of CP in Boerka receiving GCP. The N secretion in faeces and urine were significantly greater (p<0.05) than those of goat the fed with GCP proportions *C. calothyrsus* and tannin the highest (45 and 4.66%). Increased fecal N and urine nitrogen could be due to the higher tannin content of GCP, which reduced the degradation protein in the rumen. Declining in N digestibility and increased secretion of urine and feces would be as response to the increasing content of tannin in the feed[27]. The retention of N was high in R1. This might be caused by the high feed intake and digestibility of CP. The positive nitrogen balances were shown by goat fed all treatment feeds. This indicates that all treatments may have provided sufficient N for the maintenance and growth of the goats. N retention in goat fed treatment R1 has increased by 14.27% compared to control (R0), indicating the potential of green concentrate pellets in supporting the productivity of ruminants.

The average body weight (ADG), feed efficiency and blood metabolites of goats supplemented with green concentrate pellets (GCP) were shown in Table 5. Increases in the proportion of *I. zollingeriana* in GCP (p<0.05) has increased the daily body weight gain. The ADG of Boerka goats fed R1 was highest (p<0.05), but it is not significantly (p>0.05) greater than R0. The ADG of Boerka goats fed R1 was highest (102.96 g/day), but was relatively comparable to concentrates control. The feed efficiency in goats fed R1was higher (p< 0.05) than that fed R2, but it did not differ (p>0.05) when compared to R0. The plasma urea nitrogen of goats was not affected (p>0.05) by supplementation of GCP or concentrate. The plasma urea nitrogen level ranged from 56.73-60.08 mg $dL^{-1}$. The plasma urea nitrogen positively correlated with N consumption. Blood cholesterol levels in the Boerka fed GCP were lower (p<0.05) compared to these fed concentrate control (R0).

The level of feed intake of goats fed R3 is relatively high (4% BW), but the digestibilities of DM, OM and CP were relatively low to moderate (71.09, 52.45, 65.70%, respectively). The ADG obtained in this study is relatively high compared to the results of Ginting *et al.*[12] (37.3-66.8 g/day) and Tarigan and Ginting[11] (39.4-52.4 g/day), Olafadehan *et al.*[7] (65.5-73.8 g/day)

Table 6: Characteristics of rumen fermentation Boerka goats supplemented with green concentrate pellets (GCP)

| | Treatments | | | |
|---|---|---|---|---|
| Parameters | R0 | R1 | R2 | R3 |
| pH | 6.26±0.25[b] | 6.21±0.05[b] | 6.64±0.20[a] | 6.10±0.0[b] |
| $NH_3$-N (mM) | 5.08±0.87[ba] | 6.35±1.70[a] | 6.37±1.62[a] | 4.63±0.41[b] |
| Total VFA (mM) | 112.22±17.18[b] | 127.08±15.06[b] | 151.26±28.72[a] | 107.67±12.11[b] |
| **Total VFA (%)** | | | | |
| C2 | 63.60[b] | 71.03[a] | 69.95[a] | 72.42[a] |
| C3 | 27.30[a] | 20.46[b] | 19.56[b] | 17.64[b] |
| iC4 | 0.14[a] | 0.52[b] | 0.45[b] | 0.44[b] |
| nC4 | 7.03[b] | 7.05[ba] | 9.13[a] | 8.72[ba] |
| iC5 | 1.21[a] | 0.38[b] | 0.23[b] | 0.19[b] |
| nC5 | 0.72 | 0.56 | 0.69 | 0.63 |
| Rasio C2:C3 | 2.42±0.63[b] | 3.48±0.51[a] | 3.49±0.78[a] | 3.44±0.94[a] |

[a,b,c]Means within a row without a common superscript letter differ significantly (p<0.05)

and Olafadehan and Okunade[6] (71.4-86.9 g/day), Dianingtyas *et al*.[14] (72.87 g/day). Several factors such protein intake, genetic potential, the physiological state and practical management may affect ADG[14]. The efficiency of feed utilization increased as the proportion of *I. zollingeriana* GCP increased. This increase could be related to increased feed intake and feed digestibility.

Supplementing GCP did not influence the plasma urea nitrogen. The plasma urea nitrogen found in this study ranged from 56.73-60.08 (mg $dL^{-1}$) and was relatively high since it was above the normal concentration of about 20 mg $dL^{-1}$ [28]. In this study, diet were set iso-nitrogen and iso-energy, so that the intake N are similar among the treatments at a group of goat the fed with GCP similar. A positive correlation between N intake and the concentration of blood nitrogen has been reported by Turner *et al*.[29]. Blood cholesterol levels were similar among the GCP treatments, but it was lower than that fed concentrates control. Statistically, the increased proportion of *C. calothyrsus* in the GCP did not affected the blood cholesterol levels but numerically it decrease as the proportion of *C. calothyrsus* in the GCP increased. The highest blood cholesterol level was observed in the concentrate control (R0) (116.112 mg $dL^{-1}$). The decrease in the concentration of blood cholesterol in goat fed GCP could possibly due to the tannin content on feed GCP. Astuti *et al*.[30] reported a decrease in the concentration serum cholesterol in sheep fed *M. oleifera*. The reports by Astuti *et al*.[31] and Saxena *et al*.[32] indicated that the existence of a phytochemical compounds (tannin, saponin) in feed could lowered the absorption and synthesis of cholesterol.

The characteristics of rumen fermentation of Boerka goat fed green concentrate pellets (GCP) were shown in Table 6. Rumen pH was highest (p<0.05) in goats fed GCP with proportion of *I. zollingeriana* and *C. calothyrsus* was 60/30 (R2). The rumen pH of all treatment groups ranged from 6.10-6.64. This pH range seemed to be in the optimal level for ensuring rumen digestion 6.2-7.2[33]. Ammonia ($NH_3$) concentration was significantly lower (p<0.05) in goats fed GCP with the proportion of *I. zollingeriana* and *C. calothyrsus* is 45/45 (R3) compared to the goat fed GCP with the proportion of *I. zollingeriana* and *C. calothyrsus* was 60/30 (R2) and 90/0 (R1) and the concentrate control (R0). This indicated that increases in the proportion of *C. calotyhrsus* in GCP affected the concentration of ammonia ($NH_3$) of the rumen liquids of goat. The concentration of volatile fatty acids (VFA)in goat fed GCP with proportions of *I. zollingeriana* and *C. calothyrsus* was 60/30, (R2) was significantly higher (p<0.05) than those of other treatments. The concentration of acetic acid (C2) of Boerka goats fed GCP was higher (p<0.05) compared to the concentrate control (R0).The concentration of propionic acid (C3) was greater to the Boerka goat fed concentrates control (R0) (p<0.05). The rumen concentration of iso butyrate acid and n-butyrate of Boerka goat fed GCP were significantly higher (p<0.05) than the concentrate control (R0). The ruminal concentration of isovalerate rumen Boerkafed GCP were significantly lower (p<0.05) than that of the Boerka goat fed with concentrates control (R0), but the concentration n-valerate in the rumen were not different (p>0.05) among the treatments, ranging from 0.56-0.72%. The C2/C3 ratio was higher in the GCP group (p<0.05) than that of the control concentrates (R0). The rumen concentration of $NH_3$ and VFA are influenced by several factors such as, the protein and energy level in feed, time after eating, rate of absorption by rumen rumen, the degradation protein and energy and its use by rumen microbes[34]. The decline in the ratio of *I. zolinggeriana*: *C. calothyrsus* (45:45) of GCP tend to decrease the concentration of $NH_3$ of the rumen liquids, but it was not different (p>0.05) compared to the control concentrate (R0). The decrease in the concentration of $NH_3$ in a rumen liquid of goats feed GCP is an indicate tannin effect. The report by

Soliva *et al.*[35] showed that no effect on the pH and VFA rumen and decreased $NH_3$ were detected when leaves *M. oleifera* leaves was offered. The concentration of $NH_3$ of all dietary treatments were in the level of the threshold (6-21 mM) to support microbial growth[36]. The total concentration of VFA in this study ranged from 107.67-151.26 mM and were relatively proportional to that reported by Olafadehan and Okunade[6] (125-138 mM). This indicates that goat fed GCP with increase in the proportion of content *C. calothyrsus* and tannin (45 and 4.66%), have not given the negative impact on concentration VFA in rumen. This might be due to the concentrate ratio of VFA in rumen of all the GCP groups and concentrates control were all in the normal level in promoting the growth of rumen microbes (78.81-138.2 mM)[37]. Levels of acetate (C2) in the rumen increased in all GCP groups. The high levels of acetic (C2) concentration of the rumen of the goats fed GCP of high *I. zollingeriana* proportion (90%) probably related to the high rumen fermentation leading to the formation of acetate (C2). The rise in forage intake are able to encourage the increase in activity of cellulolytic bacteria in rumen, so that fermentation might lead to the formation of acetic acid[6,38]. This might related to the relatively low solubility of protein, so that amino acid are more available to be converted into the propionic acid (C3). This is supported by the fact that the concentration of $NH_3$ was especially low in goats fed treatment R3.

## CONCLUSION

Green concentrate pellets (GCP) composed of 90% *Indigofera zollingeriana* and 10% conventional ingredients given as supplement to Boerka goat gave the best results in term of the body weight gain, feed intake, nutrient digestibility, feed efficiency, ruminal fermentation and N balances. The green concentrate pellets (GCP) composing of 60% *I. zollingeriana* and 30% *C. calothyrsus* (3.33% tannin on DM) improved feed intake, concentration of $NH_3$, VFA and decrease the blood cholesterol level in goats.

## SIGNIFICANCE STATEMENT

This study discovers that green concentrate pellet based on the combination *Indigofera zollingeriana* and *Calliandra calothyrsus* can improve body weight gain, feed intake, nutrients digestibility and feed efficiency in goats. The present study also discovers that green concentrate pellets may be used to substitute up to 100% conventional concentrate supplements in ruminants. This study will help researchers to uncover the critical areas of the green concentrate pellets particularly there combination *Indigofera zollingeriana* and *Calliandra calothyrsus* for goat in which such study presently is still limited.

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