Journal of Tropical Resources and Sustainable Science

journal homepage: jtrss.org

# Effect of varying dietary energy to protein ratio in creep feed on feed intake, growth performance and nutrient digestibility of pre-weaning Boer goats

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Received 22 June 2019
Accepted 28 July 2019
Online 31 December 2019

Keywords:
Boer Goats, Creep Feed, Pre-weaning, Feed Intake, Growth Performance, Nutrient Digestibility

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## Abstract

This study was conducted to investigate the effect of dietary energy-to-protein ratios in the creep feed on feed intake, growth performance and nutrient digestibility of Boer kids before weaning. Twenty-four Boer kids, one months of age which were randomly divided into four treatment groups, with each group consisting of three males and three females. The animals were fed formulated creep feeds with varying metabolizable energy (ME) (MJ/kg DM) and crude protein (CP) contents as follows: 10 MJ ME/kg to 17% CP (Group 1, control), 10 MJ ME/kg to 18% CP (Group 2), 10 MJ ME/kg to 18% CP (Group 3) and 12 MJ ME/kg to 22% CP (Group 4). Throughout 67 days of the trial period, feed intake was found to be more in Group 3 ($P < 0.05$) compared to other groups. Dry matter intake (DMI) reduced in Group 4 when energy-to-protein ratio was increased. No significant difference ($P > 0.05$) were observed in live weight gain (LWG), body measurements and body condition score (BCS) between treatments. LWG for Groups 2 and 3 were found to be higher than the other groups. The feed conversion ratio (FCR) for Groups 1, 2, 3 and 4 were 2.21: 1, 2.50: 1, 3.57: 1 and 4.65: 1, respectively. Significant difference ($P < 0.05$) was only observed in digestibility of crude protein where Group 4 had the highest percentage of CP digestibility, however, was not translated into better BW gain in the animals of this group. The results from this study suggested that dietary formulation that contained 10 MJ ME/kg to 17% CP was sufficient to Boer goat kids at the pre-weaning stage based on LWG, body measurement, BCS and FCR.



## 1. INTRODUCTION

Under our local environment, the main problems faced by goat farmers are the high rate of mortality and the low growth rate in the kidding stage (< 3 months of age). Factors contributing to these problems could be due to the imbalance and the low plane of nutrition (Karim *et al*., 2001). Creep feeding is one of the practical approaches to enhance the growth rate of Boer kids. It is an essential component of an accelerated kidding and early weaning management program. It is accomplished by giving the kids access to extra feed or better pasture, while excluding their dams. Faster growth means kids can be marketed younger or earlier, making this an important endeavor to smallholers.

The goals of a creep feeding programme are to promote an adequate intake of palatable feed and to promote all necessary nutrients in the most economical regimen possible (Rankins & Pugh, 2012). While kids continue to suckle milk and graze, they shall also receive additional nutrients to make up for any shortfalls in intake (Yami *et al.,* 2010). Kids cannot reach optimal performance when they are feed only on their dam’s milk. The goat milk production peaks within 2 to 3 weeks after parturition. The production declines rapidly to a lower level in 8 to 10 weeks after parturition, which means the growth performance of the kids cannot rely solely on the milk supplied (Greyling *et al.,* 2004; Rankins & Pugh, 2012). Early introduction of roughage and concentrates in the diet of sucking kids could accelerate the development of the rumen (Govil *et al.,* 2017). Rumen development is greatly influenced by the density and size of the papillae that are greatly depend on type of diet, season and ruminal environment (NRC, 2007; Govil *et al*., 2017). The density of the papillae is vital in influencing the absorption of nutrients (Lane *et al.,* 2000; Lesmeister *et al.,* 2004).

The growth of goat kids shall be enhanced by feeding creep feed with adequate supply of protein (CP) and energy (ME). Protein (CP) and energy (ME) are essential components in feed formulation for effective nutrient utilization and animal growth (Karim *et al*., 2001). Energy is vital for basal metabolic process, body heat, physical activity, tissue maintenance and growth, fat deposition and lactation (Machen, 2002), while protein is



eISSN Number: 2462-2389 

used for growth and development of animals. Before weaning, goats should consume creep rations containing 12–13 MJ/kg of ME with a CP content ranging from 13 to 16% of dry matter (Yami, 2008). A commercial creep feed should contain at least 16% of CP (Hart, 2007), in the range of 15 to 18% CP (Machen, 2002). Goat kids 2 to 3 weeks of age require cereals containing CP that ranges from 14 to 15% (Wan Zahari *et al.,* 2008). The respective ME and CP recommended for kid starter are 12.3 MJ/kg (min) and 18% of CP per body weight (Department of Standard Malaysia, 2011).

The nutrient requirement for Boer goat kids under local conditions is still not well understood. There are many factors that influence their nutrition. Therefore, this study was conducted to determine a suitable dietary of energy-to-protein for growing pre-weaning Boer kids.

## 2. MATERIALS AND METHODS

### 2.1. Experimental site

The trial was conducted at the Mardi Station goat farm in Kluang Johor Bharu from September to November 2014.

### 2.2. Experimental animals and dietary treatments

Twenty-four Boer kids (three males and three females for each group), about one month of age were randomly divided into four groups of six animals based on live weight (Complete Randomized Block Design, CRBD). The live weight of the animals ranged from 5.7 to 6.0 kg. Table 1 shows the allocation of the animals and the dietary treatments.

**Table 1**: Allocation of the animals and the dietary treatments

| Group | Number of Animals | Treatment (Energy-to-Protein Ratio) |
|---|---|---|
| 1 (control) | 6 | 10 MJ ME/kg: 14% CP |
| 2 | 6 | 10 MJ ME/kg: 16% CP |
| 3 | 6 | 10 MJ ME/kg: 18% CP |
| 4 | 6 | 12 MJ ME/kg: 18% CP |

### 2.3. Feeding trial

Prior to initiation of the trial, the dams were treated for internal parasites and external parasites using Nilverm® (Tetramisole) and Intervet (Taktic EC). The dams and their kids were kept together in the group pen's compartment (5 feet x 3.5 feet). The kids had free access to their mother's milk and were assigned treatments (creep feed) throughout the day, excluding the dam's feeding time. The dams were fed twice a day for two hours i.e at 9.00 a.m. and 3.00 p.m. respectively. Drinking water was given *ad libitum*. During the dam's feeding, the kids were separated by not being allowed entrance into the pens. All the left-over feeds were removed before the kids were allowed to be with the dams for milk feeding. The kids were assigned to creep feed daily at 3.5% based on DM per their group's mean body weight. Remaining residues were weighed and discarded before fresh feed were offered for the next day. The amount of creep feed was revised every 2 weeks based on their group's body weight changes. The dams and kids were kept in the group enclosures for 8 weeks before weaning. During the feeding trial, all of the parameters studied were recorded.

### 2.4. Preparation of creep feed

The feed comprised a mixture of ground maize, soya bean meal (SBM), soya hull, palm kernel cake (PKC) and *Gliricidia sepium* leaves with an estimated total digestible nutrient (TDN) and Ca: P ratio of 67% and 2:1 respectively. The formulated supplement was self-mixed and contained the following: rice bran grade 1 (28%), urea (8%), vitamin-mineral premix for goats (2%), zeolite (10%), molasses powder (50%), and limestone (2%). It was specifically formulated to enhance CP and ME values of goat ration, as well as to increase appetite. It contained 9.0 MJ/kg DM, 33% CP, 12.5% ash, 2.3% Ca, 0.8% P and 0.21% Mg. The formulation of the feed for each treatment group is shown in Table 2.

**Table 2**: Formulation of feed for each group

| Ingredient | Group 1 (control) | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| Soya Hull (%) | 17 | 16 | 16 | 0 |
| Palm Kernel Cake (%) | 34 | 28 | 17 | 0 |
| Gliricidia (%) | 12 | 12 | 12 | 10.5 |
| Soya Bean Meal (%) | 1 | 8 | 15 | 23 |
| Ground Maize (%) | 28 | 28 | 32.5 | 56 |
| NaCI (%) | 1 | 1 | 0.5 | 0.5 |
| Molasses (%) | 5 | 5 | 5 | 6.5 |
| Limestone (%) | 1 | 1 | 1 | 1 |
| Formulated Supplement (%) | 0 | 0 | 0 | 1.5 |
| Ammonium Chloride (%) | 0.5 | 0.5 | 0.5 | 0.5 |
| Vit–mineral Premix (%) | 0.5 | 0.5 | 0.5 | 0.5 |

### 2.5. Nutrient Composition of creep feed

Each feed ingredient and formulated ration were analysed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), ash, and nitrogen free extract (NFE) according to the AOAC (2000). The results of nutrient composition for feed ingredients were used for the formulation of each treatment ration. The DM was determined by drying the samples in an oven forced dried type at 60 °C until the samples achieved constant weight. CP content was determined by using Kjedahl method. EE was determined by using Soxhlet method with petroleum ether as the extraction solvent. Determination of CF was carried out using fiber bag system according to a method provided by Gerhardt Analytical System, Germany. Ash content was determined by incineration of the sample using a muffle furnace at 600 ºC for 4 hours. NFE, which resembles digestible carbohydrate, was calculated by the difference of the DM, CP, EE, CF and ash values. Metabolizable energy (ME) was calculated according to Atwater factor system. Ca and P were determined



eISSN Number: 2462-2389 

according to the dry ashing method using atomic absorption spectrometry (AAS). All results for the analysis were expressed in a dry-matter-basis.

All the proximate analyses were conducted at the Nutrition Laboratory, Department of Veterinary Service in Kluang Johor Bharu and Nutrition Laboratory, Faculty of Veterinary Medicine, UMK.

### 2.6. Parameters studied

#### 2.6.1 Animal growth performance

##### 2.6.1.1 Feed intake

Feed intake was recorded daily by weighing the feed offered. Any remaining residue, if available was weighed before fresh feed was offered for the next day at 9 a.m.

##### 2.6.1.2 Live weight gain (LWG)

Live weight of the Boer kids was measured in the morning at the beginning of the trial and subsequently on a 2-week interval for 8 weeks.

##### 2.6.1.3 Body measurement

A flexible rule tape was used to take measurement of body length, heart girth and body circumference. A wooden ruler was used to measure body height. Body measurements were taken right after the measurement of body weight on a 2-week interval for 8 weeks.

##### 2.6.1.4 Feed conversion ratio (FCR)

FCR was calculated by dividing total feed intake (kg) with total weight gain (kg).

##### 2.6.1.5 Body condition score (BCS)

Body scoring in goats was performed using a BCS, ranging from 1.0 to 5.0 with increments of 0.5. BCS of 1.0 signified an extremely thin goat with no fat, while BCS of 5.0 signified a very over-conditioned (obese) goat (Villaquiran *et al.,* 2007). Three experienced evaluators from the academics and researchers were assigned to evaluate body condition of goat kids. The BCS was evaluated at the end of the trial by determining three body areas: lumbar, sternum (breastbone) and rib cage according to Villaquiran *et al*. (2007).

#### 2.6.2 Nutrient digestibility

A technique used to measure digestibility in animal was based on Khan *et al*. (2003) using the total collection method. After 8 weeks, at the end of the trial prior, three goat kids from each group were randomly selected for the digestibility trial. The animals were placed individually in metabolism cages with faecal collection facility. The digestibility trial involved 3 days of adaptation and 7 days faecal collection. The rations offered were similar to those used during the feeding trial. All groups received formulated rations given at 3.5% of mean body weight at 9 a.m. after daily faecal collection. Faecal output and water intake were recorded daily. Water consumption was determined by offering the goats with *ad libitum* measured quantity of water, once daily at 9 a.m., and intake was calculated by difference.

Faecal samples were collected daily from each animal at 8 a.m. by emptying the faecal containers placed separately under the metabolism cages. The faecal output was weighed. Ten percent (10%) of the collected samples were taken and dried at 60 ºC for 48 hours. The dried samples were weighed and placed into sealed plastics and stored in a dry place under room temperature. Representative faecal samples from 7 days of collection period were pooled, processed and preserved for further chemical analysis.

Samples of feed offered, residue and faecal from the digestibility trial were analysed for proximate analysis (DM, CP, EE, ash) using methods of AOAC (2000) as described earlier.

### 2.7 Statistical analysis

The raw data obtained from all the parameters in this research was presented as mean ± standard error (SE) and subjected to statistical analysis using Microsoft Excel 2010 and Statistical Package for Social Science (SPSS) Software version 20.0. The data interpretation and comparison among the treatments were justified using one-way ANOVA. The statistically different results for one-way ANOVA were subjected to further analysis using Post Hoc Multiple Comparison and Tukey Test. Differences among the means were tested for significance and according to the Tukey Test, the mean values evaluated were statistically different when $P$ value were at $\leq 0.05$.

## 3. RESULT AND DISCUSSION

### 3.1 Nutritional composition in creep feed

The estimated nutritive value of the diet in each treatment is shown in Table 3. Table 4 shows their nutritive values based on proximate and mineral analysis. There was no significant difference ($P > 0.05$) in the content of DM, ME, CF, EE, NFE, Ca, and P content among treatments. However, the significant difference ($P < 0.05$) was observed in the CP content, whereby Group 4 was significantly higher than the other groups. Group 1 (control group) had the lowest CP content (17.0%) compared to other groups.

It is evident in this trial that the nutritive values of the feeds that were determined by the chemical analysis (Table 4) were not in agreement with the estimated values based on formulation (Table 3). The differences are considered large for CP, CF, and EE analysis, with the range of variation between 0.6 and 24.0%, 14.9 and 28.9% and 8.3 and 27.4% respectively. Higher percentage of CP in Group 4 (22.2%) than the estimated value (18%) could be due to large amount of ground maize used in the ration (56%) compared to other groups that ranged from 28 to



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32.5%, whereas the level of soybean meal was already high in Group 4 (23%). In addition, large amount of both ingredients had been identified as the factor contributing to the high percentage of EE in Group 4 (2.1%) compared to other groups that ranged from 0.7 to 0.9%. Low crude fiber in Group 4 (7%) might be due to the use of *Gliricidia sepium* leaves as the main fiber source in the ration. Variations in ME, ash, Ca and P are considered small and acceptable.

Even though formulations for each ration were based on chemical analysis of the ingredients, the reason as to why the variation exists is not clear. It is possible that this is attributed to the errors during sampling prior to analysis, poor mixing of the diet at the processing stage, and errors done during chemical analysis. The results from the chemical analysis are used in this discussion, independent of the calculated values which are more theoretical.

**Table 3**: Estimated nutritive value for each treatment (in dry-matter basis)

| Estimated Nutritive Value | Group 1 (Control) | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| ME (MJ/kg DM) | 9.72 | 9.80 | 9.93 | 11.5 |
| CP (%) | 14.1 | 16.1 | 17.9 | 17.9 |
| CF (%) | 13.5 | 12.7 | 11.5 | 6.05 |
| EE (%) | 3.42 | 3.37 | 3.39 | 3.85 |
| Ash (%) | 5.73 | 5.93 | 6.05 | 5.92 |
| NFE (%) | 56.9 | 55.1 | 54.2 | 56.1 |
| TDN (%) | 67.4 | 67.8 | 69.4 | 70.4 |
| Ca (%) | 0.85 | 0.85 | 0.87 | 0.81 |
| P (%) | 0.41 | 0.41 | 0.41 | 0.33 |
| Ca:P | 2.1:1 | 2.1:1 | 2.1:1 | 2.5:1 |

**Table 4**: The composition of experimental creep feed between treatments

| Nutritive Value | Group 1 (Control) (Mean±SE) | Group 2 (Mean±SE) | Group 3 (Mean±SE) | Group 4 (Mean±SE) |
|---|---|---|---|---|
| Moisture (%) | 11.20$^{a}$±0.14 | 12.50$^{a}$±0.57 | 11.15$^{a}$±0.21 | 12.00$^{a}$±0.71 |
| DM (%) | 88.80$^{a}$±0.14 | 87.50$^{a}$±0.57 | 88.85$^{a}$±0.21 | 88.00$^{a}$±0.71 |
| ME (MJ/kg) | 9.51$^{a}$±1.54 | 9.69$^{a}$±0.27 | 9.56$^{a}$±0.35 | 11.92$^{a}$±0.88 |
| CP (%) | 17.00$^{a}$±0.57 | 17.90$^{a}$±0.99 | 17.80$^{a}$±0.14 | 22.20$^{b}$±0.57 |
| CF (%) | 17.40$^{a}$±0.85 | 15.70$^{a}$±2.83 | 16.05$^{a}$±4.60 | 6.95$^{a}$±0.64 |
| EE (%) | 0.75$^{a}$±0.64 | 0.90$^{a}$±0.85 | 0.70$^{a}$±0.28 | 2.10$^{a}$±0.99 |
| Ash (%) | 6.65$^{a}$±1.2 | 7.40$^{a}$±1.84 | 5.90$^{a}$±0.28 | 6.65$^{a}$±0.07 |
| NFE (%) | 58.20$^{a}$±0.85 | 58.15$^{a}$±4.74 | 59.55$^{a}$±4.17 | 62.10$^{a}$±0.28 |
| Ca (%) | 0.78$^{a}$±0.16 | 0.88$^{a}$±0.33 | 0.42$^{a}$±0.02 | 0.45$^{a}$±0.00 |
| P (%) | 0.40$^{a}$±0.00 | 0.39$^{a}$±0.03 | 0.46$^{a}$±0.04 | 0.49$^{a}$±0.04 |
| Ca:P | 2:1 | 2:1 | 1:1 | 1:1 |

Note: Group 1 (control): 10 MJ ME/kg 17% CP, Group 2: 10 MJ ME/kg 18% CP, Group 3: 10 MJ ME/kg 18% CP, Group 4: 12 MJ ME/kg 22% CP, $^{a,b,c}$ Mean values with different superscripts are significantly different (*P* value < 0.05), DM: dry matter, ME: metabolize energy, CP: crude protein, CF: crude fiber, EE: ether extract, NFE: nitrogen free extract, Ca: calcium, P: phosphorus, SE: standard error of means.

### 3.2 Effect of dietary treatment on DMI and growth performance

The DMI and growth performance of the animals for the respective treatment is shown in Table 5.

**Table 5:** DMI and Growth performance of different dietary groups of Boer kids

| Parameters | Treatments | | | |
|---|---|---|---|---|
| | Group1 (control) (Mean±SE) | Group 2 (Mean±SE) | Group 3 (Mean±SE) | Group 4 (Mean±SE) |
| DMI (kg/day) | 0.17$^{a}$±0.14 | 0.23$^{b}$±0.10 | 0.32$^{c}$±0.09 | 0.26$^{b}$±0.05 |
| ADG (kg/day) | 0.08$^{a}$±0.02 | 0.09$^{a}$±0.02 | 0.09$^{a}$±0.02 | 0.07$^{a}$±0.05 |
| Body measurement (cm/day) | | | | |
| Height | 0.15$^{a}$±0.06 | 0.11$^{a}$±0.02 | 0.15$^{a}$±0.04 | 0.13$^{a}$±0.03 |
| Length | 0.11$^{a}$±0.04 | 0.11$^{a}$±0.03 | 0.14$^{a}$±0.06 | 0.13$^{a}$±0.07 |
| Girth | 0.14$^{a}$±0.02 | 0.16$^{a}$±0.03 | 0.18$^{a}$±0.03 | 0.15$^{a}$±0.04 |
| Circumference | 0.17$^{a}$±0.05 | 0.16$^{a}$±0.02 | 0.21$^{a}$±0.04 | 0.17$^{a}$±0.05 |
| FCR | 2.21$^{a}$±0.47 | 2.50$^{a}$±0.33 | 3.57$^{ab}$±0.80 | 4.65$^{b}$±2.33 |
| BCS | 3.0$^{a}$±0.22 | 3.0$^{a}$±0.38 | 3.0$^{a}$±0.22 | 3.0$^{a}$±0.45 |

Note: Group 1 (control): 10 MJ ME/kg 17% CP, Group 2: 10 MJ ME/kg 18% CP, Group 3: 10 MJ ME/kg 18% CP, Group 4: 12 MJ ME/kg 22% CP. $^{a,b,c}$ Mean values with different superscripts are significantly different (*P* value < 0.05), DMI: dry matter intake, ADG: average daily gain, FCR: feed conversion ratio, BCS: body condition score, SE: standard error of means.

#### 3.2.1 DMI

There were significant differences ($P < 0.05$) in DMI among groups, except between Group 2 and Group 4. The highest DMI was achieved by Group 3, while the lowest value was in the control group. The increment of DMI for Group 2, 3 and 4 over the control group were 35.3%, 88.2%, and 52.9% respectively.

Factors governing the feed intake in ruminant include the following: (i) animal-related factors such as physiological stage, growth and age, size and animal's genotype); (ii) feed-related factors such as nutritive value of a given feedstuff, chemical and physical characteristics of feed, sward structure in grazing animals, associative effects among dietary components, nutrient balance and amount of anti–nutritive factors (ANF); and (iii) environmental-related factors including temperature, housing, availability of water, and prevalence of disease (McDonald *et al.*, 2002; Zereu, 2016). Data on feed intake from the present study revealed that, at a similar dietary energy concentration of 10 MJ ME/kg, the animal's consumption was increased with the increasing level of CP (17–18% CP). Group 3, which received 18% CP consumed more feed than other groups with the increment of 61.75% compared to the control group (17% CP). The present study demonstrates that the feed intake increased as protein content increased. Previous reports indicated that an increase intake of dietary CP resulted in increased feed intake (Huston *et al.*, 1988; Cheema *et al.*, 1991).



eISSN Number: 2462-2389 

Similarly, Reddy *et al*. (2002), and Reddy and Linga Reddy (2003) also supported the present findings that high protein had increased both dry matter and nutrient intakes of the animals. Increasing levels of CP from 8.7 to 17.6% were reported to increase the DMI of goat kids (Negesse *et al.*, 2001). During growth, goat kids regulated feed intake to satisfy their nutrient requirements, whereby protein intake was increased to fulfil energy requirements (Hadjipanayiotou & Sanz, 1997).

However, Prieto *et al*. (2000), Sharifi *et al*. (2013), and Rashid (2013) reported no significant difference in DMI with increasing protein levels in the goat rations. Hwangbo *et al*. (2009) also reported no significant difference in DMI when the CP level was increased from 14% to 20%.

In the present study, DMI was decreased about 52.9% in Group 4 when energy and CP contents were increased to 12 MJ ME/kg and 22% respectively. The reasons could be associated with excessive dietary energy or protein density. Higher intake of dietary CP could result in increased feed intake. However, excessive consumption of protein could influence the intake of creep feeds in order to fulfil the requirement for growth. Previous report indicated that DMI was reduced when animals consumed 21.4% of dietary CP than those receiving 14.3% CP (Karim *et al.*, 2001). The depression of DMI in animals receiving 22% of CP could be due to excessive consumption of protein since the kids obtained an adequate amount of protein from their dam's milk. When energy content is increased in the diet, the animals tend to consume less feed due to certain mechanisms controlling energy intake. The depression of DMI when dietary ME was increased was also reported by Lu and Potchoiba (1990). In the present study, the intake of ME appeared to be a primary factor that influenced the DMI of the animals when the ration containing above 10.29 MJ ME/kg DM was offered. Similarly, when the deposition of fat was increased in growing goats with increasing energy density, the response of adipose tissue would also affect control of feed intake (Jindal *et al.*, 1980). A finding in a study of sheep revealed that high energy content in the diet had decreased feed intake and the animals would stop eating when the energy has been fulfilled (Mawati *et al*., 2013).

The depression in feed intake in the present study could also be affected by the type of feed ingredient and degradation rate in the rumen (rumen emptying time) (Mawati *et al.*, 2013). A high proportion of concentrate (23% SBM and 56% ground maize) in Group 4 (Table 2) could be one of the reasons that limited the DMI. DMI was reported to decrease linearly when the level of concentrate was increased from 50 to 90% (Corrigan *et al.*, 2008). In their study, the DMI of Boer crossbred kids fed 90% concentrate was reported to be the lowest, apart from causing urolithiasis. Goetsch *et al.* (2003) and Urge *et al.* (2004) reported that the DMI in goats consuming 75% concentrate was numerically lower compared to a 50% concentrate diet. The reduction of DMI attributed to the high proportion of concentrate in the ration could be related to the depression of ruminal pH, due to the accumulation of lactic acid in the rumen (Abijaoudé *et al.*, 2000; Jaramillo-Lopez *et al.*, 2017). When lactic acid is absorbed in the circulatory system, it will alter the systemic and ruminal acid balance, water balance, and feed intake. Cereal starch (such as maize) can be quickly degraded in the rumen, producing a large amount of lactic acid that exceeds the rumen's absorption capacity. Therefore, in the present study, a high proportion of concentrate (especially ground maize), which had rapidly degraded in the rumen, might be the contributing factor that reduced the DMI in the group 4 as compared to other treatment groups.

The range of DMI for the pre-weaning Boer kids in this study was from 0.17 to 0.32 kg/day, which can be considered sufficient to increase their performance. From 3 weeks of age to weaning, goat kids usually consume more than 0.23 kg/day to increase their performance (Rankins *et al.*, 2002). The amount that the animal received could not indicate the actual growth performance of the animals as the kids still consumed milk from their dams.

### 3.2.2 ADG

There was no significant difference ($P > 0.05$) in ADG among treatments. Group 2 and 3 tended to have higher ADG, while Group 4 had the lowest gain as compared to the other groups. The increment of ADG for Groups 2 and 3 over the control group was approximately 12.5% per day. Animals in Group 4 had 12.5% lower ADG than that of the control group's.

Throughout the 67 days feeding period, provision of daily rations with the energy content of 10 MJ ME/kg DM and increasing level of CP from 17 to 18% had no effect on the ADG of the goat kids. Similarly, no significant effect was detected when energy content was increased to 12 MJ ME/kg DM and 22% CP (Group 4). No significant difference was also observed when Korean black goats were fed with rations containing 10 ME MJ/kg but with varying CP content (14%, 16% and 20%) (Hwangbo *et al.*, 2009). Studies in Thailand revealed that different levels of ME (11.34 and 12.2 MJ/kg DM) and protein (10%, 12% and 14%) did not affect the growth rate of goats (Kuprasert *et al.*, 2000). Different levels of protein (14%, 16% and 18%) had no significant effect on the performance of Dorper or Pelibuey lambs (Nuno *et al.*, 2009).

In contrast to the present study, Hart *et al.* (1993), Jia *et al.* (1995) and Choi *et al.* (2005) reported an increase in ADG with increased dietary CP concentration. The ADG of black Bengal goats was increased when the animals were fed 20.3% CP as compared to those receiving 16.9% and 20.3% CP (Shahjalal *et al.*, 2000). The variation in CP utilization could be influenced by many factors,



eISSN Number: 2462-2389 

which include breed, type of feed, growth phase, and environmental factors (Negesse *et al.*, 2001).

Increased DMI had resulted in increased ADG in groups that were fed daily rations of 10 MJ ME/kg and 17–18% CP (Group 1, 2 and 3). The ADG was significantly reduced when DMI was decreased in Group 4 (12 MJ ME/kg and 22% CP). As the proportion of intake was decreased, the availability of nutrients was also reduced, resulting in body weight loss, poor growth and low FCE (Zereu, 2016). In the present study, CP level higher than 18% did not result in improved growth performance of the animals and this could be due to an imbalance of energy to protein availability in the ration. Hence, under this circumstance, higher level of energy might be required for optimum utilization of dietary CP. At 15% CP in the ration of Korean black goats, the optimal energy requirement was 12.6 MJ ME/kg (Choi *et al.,* 2007). Utilization of dietary CP for animal growth was reported to have decreased when energy level was deficient, since higher dietary CP utilization was closely related to energy provision (Titi *et al.*, 2000). Feeding ration that contained 10 MJ ME/kg with > 18 % CP did not result in increased growth performance of Korean Black goat kids (Titi *et al.*, 2000; Hwangbo *et al.*, 2009). Studies on West African dwarf goats reported highest N absorption when the animals were fed ration containing 17% CP and decreased when the CP level was > 17% (Osuagwuh & Akinsoyinu, 1990).

The present trial indicates that the optimum level of a dietary CP could be from 18 to 20% for fast growth, provided that the ME concentration is equal or above than 10 MJ ME/kg DM. This merits further evaluation. The range of ADG of Boer kids in pre-weaning achieved in this study, i.e. from 0.07 to 0.09 kg/day can be considered normal under tropical-humid condition. The LWG was 0.62 g/day from birth to 10 kg LW and 0.14 kg/day from 10 kg to 23 kg LW (Van Nickerk & Casey, 1988). Under good pastoral conditions, growth rate of 0.240, 0.238, and 0.218 kg/day were recorded for single, twin, and triplets Boer kids raised in Namibia, respectively (Barry & Godke, 1997). Meanwhile, the ADG of Boer kids in pre-weaning was 116.9 g/day as reported by Browning and Leite-Browning (2011).

### 3.2.3 FCR

There was a significant difference ($P$ < 0.05) in Group 3 and Group 4 over the control group. Group 1 had the lowest FCR value, followed by Group 2 and 3, while Group 4 had the highest FCR value.

In the present study, the FCR value had numerically increased as the CP level increased from 17 to 18% and had significantly increased as the CP level was elevated from 18 to 22%. Group 2 numerically had a lower FCR value, indicating a better feed-to-meat ratio conversion compared to Group 3 with a similar content of ME and CP (10 MJ ME/kg and 18% CP). However, the FCR value was reported to have decreased significantly as the CP level was increased from 14 to 20% CP (Hwangbo *et al.*, 2009). Better FCR in Group 2 than Group 3 might be associated to DMI of the animals since the DMI in Group 3 was significantly higher than of Group 2's, while the ADG for both treatments were similar (90 g/day).

Poor FCR in animals consuming 12 ME MJ/kg and 22% CP (Group 4) could also be linked to the high consumption of concentrate in the ration, causing a higher accumulation of lactic acid in the rumen. Large amount of lactic acid can decrease ruminal pH, which subsequently depresses both DMI and FCR. Depression of pH was reported to affect the relationship of feed efficiency to absorb feed (Casper, 2008). In ruminant animals, the FCR can be influenced by many factors, which include efficiencies of fermentative digestion, composition of rumen microbial populations, and feed intake (Leng, 1989).

FCR in the range of 4–5:1 was considered ideal for kids consuming high concentrate rations as compared to 5–6:1 on the good quality of forages. FCR above 6:1 indicated poor ration quality. The FCR in Boer kids are as efficient as lamb's (Naude & Hofmeyr, 1981) and should be in the range of 5 or less per 1 kg of feed consumed (Machen, 2002). The FCR of Korean black goats were 7.1, 6.6, 6.2 and 6.5 when consuming rations containing 14%, 16%, 18% and 20% CP respectively (Hwangbo *et al.*, 2009).

### 3.2.4 Body measurement

There was no significant difference ($P$ > 0.05) in BH, BL, HG, and BC among treatments. Over the 67 days trial period, though not statistically significant, the highest gain in height was observed in Group 3 and Group 1 (the control group), followed by Group 4 and 2. Group 3 has a similar height gain to the control group. The highest gain in body length was observed in Group 3 followed by Group 4, Group 1 (the control group) and Group 2. The increment of gain in body length for Groups 3 and 4 over the control group was 27% and 18% respectively. Additionally, Group 3 had highest values of gain in heart girth, followed by Groups 2, 4 and the control group. The increments of gain in heart girth over the control group were 29%, 14% and 7% respectively. Group 3 tended to have highest gain in body circumference as compared to other treatment groups with the increment of 24% over the control group. Meanwhile, Group 2 had the lowest gain in body circumference, with the increment of 6% lower than the control group.

At similar dietary concentrations of 10 MJ ME/kg and CP level of 17–18%, body measurements were observed to have increased, except in Group 2 whereby lower body measurements (height and circumference) recorded amounting to 27% and 6% respectively lower than those in the control group. Group 3, receiving 18% CP



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level, had the highest gain in body measurements. The depression of gain in body measurements in Group 4 (12 MJ ME/kg and 22% CP) was attributed to decreased ADG. Hence, increasing the ADG will increase the gain in body measurements.

The body measurements pointed out some insight into the relationship between frame and skeletal size with the live weight, breed, and stage of maturity, but were inaccurate to estimate the muscle, fat, and bone content of the animals (NRC, 1988). Khan *et al.* (2006) reported that body measurements had a high correlation with the body weight of goats. In contrast, Lawrence and Fowler (2002) indicated that, the prediction of live weight and tissue deposition in carcasses from live body measurement is poor, since animals have different shapes and sizes. Apart from live weight, body measurements such as body length, width of the pelvis, height at withers, and chest girth of an animal can be used as the parameters to evaluate the body conditions of live animals (Attah *et al.,* 2004).

#### 3.2.5 BCS

There was no significant difference ($P$ > 0.05) in the BCS among treatments, as the animals were in similar body condition (3.0), indicating that the animals were in good BCS. Body condition of 2.5–4.0 indicated a healthy goat (Villaquiran *et al.,* 2001).

### 3.3 Effect of dietary treatment on nutrient digestibility

Digestibility of nutrients (DM, CP, EE, CF, ash and NFE) and minerals (Ca and P) by the animals after the feeding trial is shown in Table 6.

**Table 6**: Dry matter and nutrient digestibility of pre-weaning Boer goats among treatments

| Parameters | Treatments | | | |
|---|---|---|---|---|
| | Group1 (Control) (Mean ±SE) | Group 2 (Mean±SE) | Group 3 (Mean±SE) | Group 4 (Mean±SE) |
| DM (%) | $70.92^{a}$± 2.87 | $69.65^{a}$± 3.11 | $68.25^{a}$±3.46 | $74.48^{a}$±0.50 |
| CP (%) | $78.68^{a}$± 2.28 | $76.45^{a}$±3.54 | $77.68^{a}$±1.19 | $86.72^{b}$±1.03 |
| EE (%) | $62.94^{a}$± 12.53 | $89.42^{a}$±1.17 | $61.96^{a}$±16.63 | $75.88^{a}$±10.76 |
| CF (%) | $67.75^{ab}$ ±1.74 | $62.07^{ab}$± 5.80 | $72.06^{a}$±1.83 | $59.24^{b}$± 5.25 |
| Ash (%) | $79.57^{a}$± 5.17 | $71.33^{a}$±7.43 | $72.54^{a}$±6.47 | $79.79^{a}$±1.36 |
| NFE (%) | $68.59^{a}$± 4.38 | $68.78^{a}$±2.43 | $63.58^{a}$±5.59 | $70.39^{a}$±2.18 |
| Ca (%) | $79.03^{a}$± 2.83 | $73.36^{a}$±12.31 | $73.11^{a}$±0.25 | $76.60^{a}$±1.42 |
| P (%) | $64.74^{a}$± 11.80 | $56.99^{a}$±10.77 | $68.92^{a}$±14.92 | $77.72^{a}$±3.54 |

Note: Group 1 (control): 10 MJ ME/kg 17% CP, Group 2: 10 MJ ME/kg 18% CP, Group 3: 10 MJ ME/kg 18% CP, Group 4: 12 MJ ME/kg 22% CP. $^{a,b,ab}$ Mean values with different superscripts are significantly different ($P$ < 0.05), DM: dry matter, CP: crude protein, EE: ether extract, CF: crude fiber, NFE: nitrogen free extract, SE: standard error of means.

No significant difference ($P$ > 0.05) was observed in DM digestibility among treatments. Group 4 had the highest percentage of DM digestibility, followed by the control group, Group 2, and 3 with the increment of 3.6% over the control group.

There was a significant difference ($P$ < 0.05) in CP digestibility among treatments, with Group 4 tended to have the highest CP digestibility compared to other groups with increment of 8% over the control group. The lowest CP digestibility was in Group 2, 2% lower than the control group.

There was no significant difference ($P$ > 0.05) in EE digestibility, with Group 2 tended to have highest EE digestibility and Group 3 had the lowest EE digestibility, with the increment and reduction of 26% and 1% over the control group respectively.

There was a significant difference ($P$ < 0.05) in CF digestibility among groups. However, no significant difference ($P$ > 0.05) was observed between the control group and Group 3 as well as between the control group and Group 4. Group 3 had significantly highest CF digestibility with increment of 4.3% over the control group, while Group 4 had significantly lowest CF digestibility compared to other treatments, 8.5% lower than the control group.

There was no significant difference ($P$ > 0.05) in the ash and NFE digestibility. In terms of mean values, Group 4 had the highest ash digestibility compared to the control, Group 3 and Group 2. Group 4 was observed to have the highest NFE digestibility followed by Group 2, control group and Group 3.

No significant difference ($P$ > 0.05) was observed in Ca and P digestibility among treatments. The control group had highest Ca digestibility, followed by Group 4, Group 2 and Group 3. Group 4 had the highest P digestibility, followed by Group 3, the control group and Group 2.

In the present study, the digestibility of DM, EE, ash, NFE, Ca and P was unaffected by dietary treatments when ME of the rations ranged from 10 to 12 MJ ME/kg DM and CP level increased from 17 to 22%. Another study reported that DM digestibility was similar in pre-weaning lambs receiving dietary CP that ranged from 18 to 27% (Santra & Karim, 1999). However, Olson *et al.* (1999) indicated that DM digestibility increased linearly with increased protein supplementation. Digestibility of CP was significantly higher when animals consumed ration that contained 12 MJ ME /kg and 22% CP (Group 4). A similar result was also reported by Paengkoum *et al.* (2011), whereby CP digestibility was increased with increased level of CP. However, high CP digestibility in Group 4 did not result in improved LWG, which could be linked to depressed DMI. Santra and Karim (1999) reported that high consumption of dietary protein at 22% and 27%

allows protein to be utilized in the energy cycle instead of adding to the accretion of body tissue.

The DM and CP digestibility in the current trial ranged from 68.25 to 74.49% and 76.45% to 86.72% respectively. These values indirectly indicated that the rations used for feeding the animals, regardless of the treatments, were easily digested. Dry matter digestibility that ranged from 50 to 55% is sufficient for ruminant animals (Djajanegara, 1983). DM and CP digestibility in goats fed with mixed Napier grass and commercial pellets were 64.1% and 68.4% respectively (Rahman *et al.*, 2013).

## 4. CONCLUSION

In conclusion, nutrition at the pre-weaning stage is very important in ensuring optimum growth rate and survivality of Boer goat kids after birth. Boer goat kids can be weaned between 8 and 10 weeks of age and the animals must be adapted to a high-quality solid feed if they are to be weaned young and for better performance at latter stage. Creep feed containing 10 MJ ME/kg DM to 17% CP is sufficient enough for pre-weaning Boer goats to enhance growth rate of Boer goat kids at the pre-weaning stage based on gain live weight (LWG), body measurement, body condition score (BCS) and feed conversion ratio (FCR). In term of nutrient digestibility, Boer kids consuming 10 MJ ME/kg DM and 22% CP performed better digestibility of DM and CP however were not translated into LWG of the animals in this group.

## ACKNOWLEDGEMENT

We would like to express our appreciation to the Ministry of Higher Education (MOHE) of Malaysia for giving us the Fundamental Research Grant (Entitled: Creep feeds Formulation For Boer Goats Kids To Enhance Growth and Survival (R/FRGS/A06.00/00534A/002/013/00116) to conduct this study.

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