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Potential of Leucaena (*Leucaena leucocephala*) for Compensatory Growth on Anglo-Nubian Crossbred Male Goats

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Abstract

This study was carried out to evaluate the potential of leucaena (*Leucaena leucocephala*) as the sole diet after restriction of feeding in order to elevate compensatory growth during re-alimentation. Twelve Anglo-Nubian crossbred male goats, with an average body weight of 17.50 kg, were assigned to 3 treatments, with 4 replicates, in a completely randomized design (CRD), where all treatments were under 3 feeding regimes, *viz*. pre-feed restriction, feed restriction, and re-alimentation. All animals were allotted to normal feeding and fed with Pangola hay and meal concentrate to promote an average daily gain (ADG) of 100 g in the initial period for 3 weeks. During the feed restriction period, animals in Treatment 1 were continuously fed at the same level as in the pre-restriction (normal growth/control group), while the animals in Treatments 2 and 3 (restricted groups) were kept at feeding levels of 47.5 and 67.5 % below maintenance, based on NRC (2007), for 4 weeks. In the final period of re-alimentation (7 weeks), the normal growth group was given Pangola hay and meal concentrate at the same level as in the pre-restriction period while restricted groups were subjected to *ad libitum* sole leucaena feeding until the end of the trial. The results showed that average daily gain (ADG) and feed intake did not differ among the treatments during the pre-feed restriction while, in the restriction feeding period, the restricted groups had lower means ($P < 0.01$) than the normal growth group. In the re-alimentation period, total dry matter intake was not significantly different among treatments. It is pointed that there were 2 sub-periods during the re-alimentation period where total dry matter intake during the compensatory growth and the normal growth were not significantly different. However, the compensatory growth had been achieved within 2 weeks, indicating a higher ADG of 141.25 and 158.57 g in the restricted groups, compared to 106 g in the control group. Afterwards, the sub-period of normal growth (5 weeks) was followed with a lower ADG in the restricted groups than that in the control group. It can be concluded that the potential of single leucaena feeding for compensatory growth after restriction feeding can be achieved within a short period during re-alimentation, due to the limitation of fiber enrichment in leucaena.

Keywords: Goats, compensatory growth, feed restriction, *Leucaena leucocephala*

Introduction

Goat feeding with good quality roughage has been investigated to achieve animal production with a low cost of production [1,2]. Goat meat production can be provided with good quality pasture to obtain an optimum daily gain. Therefore, pasture must be provided sufficiently to meet growth requirements. To have a better growth performance, meal concentrate can be supplemented to meet the higher requirements for such improvement [3]. Tropical legume is an alternative source of protein for better nutritive values to improve ruminant production [4]. Leucaena (*Leucaena leucocephala*), a promising tropical tree legume of high protein content of 17 - 30 %, can be fed to ruminants without causing any harm [5]. It is a preferably accessible, good quality forage legume used to cut and carry roughage for fresh and single diets for goat in the tropics, especially in Thailand [6].

During dry season, pastures are in short supply and, consequently, goats are in poor body condition. Compensatory growth is a condition of the accelerated growth of an animal provided with good quality feed after a period of slowed growth (poor body condition), particularly as a result of nutrient deprivation. By this physiological process, an animal accelerates its growth after a period of restricted establishment, normally because of reduced feed intake [7,8]. There have been many studies showing that animals recover faster after a feed restriction with a different source of feed supplement in the re-alimentation period, such as concentrate and alfalfa hay, total mix ratio (TMR), and soybean meal [7,9-11]; however, leucaena as sole feed has not yet been observed.

Whereas the potential of leucaena in term of nutritive value and animal productivity has been clearly documented in many sources, the potential of this legume as a source of diet for assisting an animal to recover after malnutrition and catch up with the normal growth rate has not been investigated. Thus, this experiment was designed to study compensatory growth of Anglo-Nubian crossbred goats after feed restriction and then feeding with a sole diet of leucaena in the re-alimentation period.

Materials and methods

Description of research location

The study was conducted at Luang Suwanvajokkasikit Farm in Kasetsart University, Bangkok, at a latitude of 13°50'N and a longitude of 100°34'E, with an elevation of 11 m above sea level. The relative humidity is 69 %, with an average annual rainfall of 1498 mm, and with minimum and maximum average temperatures of 15 and 43 °C, respectively. April was the most thermal month of this year in the experiment.

Experimental design and treatments

The experiment was conducted within 14 weeks of 3 periods of different feeding regimes. Twelve crossbred Anglo-Nubian bucks (≥ 75 % Anglo-Nubian and Native), averaging 1 - 1.5 years old and approximately 17.5 kg live weight, were assigned to 3 treatments, with 4 replicates each, in a complete randomized design (CRD), where all treatments were under 3 periods of feeding regime, viz. pre-restriction, restriction, and re-alimentation periods;

1. The pre-restriction period- animals in Treatment 1 as the control group of normal growth were fed with Pangola hay and meal concentrate according to their nutrient requirement, similar to Treatments 2 and 3. This period was conducted for 3 weeks to promote an average daily gain (ADG) of 100 g [3].
2. The restriction period (4 weeks)- animals in Treatment 1 were continuously fed with Pangola hay and meal concentrate at the same level as in the pre-restriction period. The feeding practice for animals in Treatments 2 and 3 was subsequently applied at 2 levels, namely, 47.5 and 67.5 % below maintenance [3], respectively. The feeding regime in this period used only Pangola hay at a limited amount to achieve low maintenance levels according the treatments.
3. The final period of re-alimentation was done for 7 weeks in all treatments. Treatment 1 was still given Pangola hay and meal concentrate at the same level as in the pre-restriction period. Meanwhile, the animals in Treatments 2 and 3 were subjected to *ad libitum* sole leucaena feeding until the end of the trial.

There was a 12 day adaptation before the pre-restriction period began, and a transitional period of 7 days for the adaptation to the restriction and re-alimentation feeding regimes.

During the experiment, Pangola hay and dried leucaena (leaves and immature branches) were mechanically chopped into 2 - 3 cm lengths. Meal concentrate was offered twice daily (in the morning and evening). Chopped hay was provided at any time of the day until it was almost used up. Each goat was individually housed in a pen of 2.5 m wide and 2 m long under a tiled roof barn with free access to water and mineral block. They were de-wormed before the experiment.

Sampling and laboratory analyses

Feed intake was determined daily as the difference between feed offered and refuse collected. DM percentage of roughage and meal concentrate was used to calculate daily dry matter intake. The animal body weight was measured weekly, while the average daily gain was calculated as the difference between the initial and final body weights divided by the interval of the experimental period (14 weeks).

Samples of meal concentrate, Pangola hay, and leucaena were collected and analyzed for dry matter (DM) content and crude protein (CP) by Kjeldahl analysis [12]. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to the method of Soest *et al*. [13]. Gross energy (GE) was determined using Oxygen Bombs [14].

Statistical analysis

All data were statistically analyzed using the analysis of variance for Completely Randomized Design, according to the statistical methods outlined in [15]. Data were subjected to statistical analysis using the SPSS Statistical Package. Significant differences among treatments were assessed by Duncan's new multiple range test at a significance level of 0.05. The comparison between control and restriction groups was also tested by orthogonal contrast [15].

Results and discussion

Chemical composition of feeds

The chemical composition of the experimental diets is summarized in **Table 1**, where Pangola hay contained DM, CP, NDF, ADF, and GE of 915.2, 51.6, 542.3, 324.4 g/kg DM and 3,429.22 cal/g DM, respectively, while the DM, CP, NDF, ADF, and GE of leucaena were 918.2, 205.5, 384.1, 273.8 g/kg DM and 3,743.55 cal/g DM, respectively.

Table 1 Chemical composition (g/ kg) of the experimental diets.

Composition	Pangola Hay	Concentrate	Dried Leucaena
Dry Matter (g/kg)	915.2	908.1	918.2
	On dry matter basis		
Crude Protein	51.6	145.7	205.5
NDF	542.3	322.9	384.1
ADF	324.4	132.6	273.8
GE (cal/g DM)	3,429.22	3,377.24	3,743.55

Table 2 Dry matter intake (DMI) of Anglo-Nubian crossbred goats among the feeding periods.

Items	Treatments			SEM	P-value	Orthogonal contrast
	T1 (C)	T2 (M)	T3 (S)			T1 vs. T2,T3
1. Pre-restriction Period						
Feeding period (week)	3	3	3			
Total dry matter intake (g DM/h/d)	663.63	682.41	667.89	17.40	0.917	0.797
- Concentrate	490.81	479.63	479.15	-	-	-
- Pangola hay	172.83	202.77	188.74	-	-	-
Protein intake (g DM/h/d)	80.43	80.35	79.55	1.28	0.961	0.884
NDF intake (g DM/h/d)	252.21	264.84	257.07	8.74	0.870	0.696
ADF intake (g DM/h/d)	121.15	129.38	124.76	5.06	0.841	0.647
Total DMI to % BW	3.28	3.39	3.21	0.06	0.439	0.885
2. Restriction Period						
Feeding period (week)	4	4	4			
Total dry matter intake (g/hd/d)	703.49[a]	352.36[b]	218.22[c]	62.36	< 0.001	< 0.001
- Concentrate	499.46	-	-	-	-	-
- Pangola hay	204.04	352.36	218.22	-	-	-
Protein intake (g DM/h/d)	83.30[a]	18.19[b]	11.26[c]	9.80	< 0.001	< 0.001
NDF intake (g DM/h/d)	271.92[a]	191.08[b]	118.34[c]	19.55	< 0.001	< 0.001
ADF intake (g DM/h/d)	132.42[a]	114.31[a]	70.79[b]	8.34	< 0.001	< 0.001
Total DMI to % BW	2.98[a]	1.74[b]	1.20[c]	0.24	< 0.001	< 0.001
3. Re-alimentation Period						
Feeding period (week)	7	7	7			
Total dry matter intake (g/hd/d)	796.54	721.31	714.94	26.02	0.400	0.189
- Concentrate	499.46	-	-	-	-	-
- Pangola hay	297.08	-	-	-	-	-
- Leucaena	-	721.31	714.94	-	-	-
Protein intake (g DM/h/d)	88.10[b]	148.23[a]	146.92[a]	9.67	0.001	< 0.001
NDF intake (g DM/h/d)	322.38	277.05	274.61	11.41	0.157	0.061
ADF intake (g DM/h/d)	162.60	197.49	195.75	8.11	0.138	0.053
Total DMI to % BW	2.59[b]	3.12[a]	3.13[a]	0.10	0.024	0.008
3.1 Compensatory growth						
Feeding period (week)	2	2	2			
Total dry matter intake (g/hd/d)	731.90	594.31	594.38	29.02	0.066	0.023
- Concentrate	499.46	-	-	-	-	-
- Pangola hay	232.44	-	-	-	-	-
- Leucaena	-	594.31	594.38	-	-	-
3.2 Normal growth						
Feeding period (week)	5	5	5			
Total dry matter intake (g/hd/d)	822.39	772.11	763.17	26.62	0.663	0.383
- Concentrate	499.46	-	-	-	-	-
- Pangola hay	322.93	-	-	-	-	-
- Leucaena	-	772.11	763.17	-	-	-

Means in the same row with different lowercase superscripts are significantly different ($P < 0.05$).

The nutritional value of Pangola hay varies with several factors of different harvesting periods, the application of fertilizer, plant station, climate, and environment [16]. The CP content of Pangola hay is in the range from 31 - 70 g/kg of DM [17-19]. Good quality Pangola hay should contain high protein of 70 g/kg or more [20]. However, the quality class of Pangola hay used in this experiment was categorized in class D1, where CP and ADF contents were < 70 and < 350 g/kg DM, respectively [20]. Apparently, Pangola hay contained high NDF content of 542.3 g/kg DM, which would have a negative correlation with energy density and be positively correlated to gut fill, hence, correlated to both functions of intake mechanism [21]. Moreover, the ADF content in Pangola hay of 324.4 k/kg DM might have a negative correlation with dry matter digestibility [20].

Dried leucaena used in this experiment contained more leaf with green stem, affecting the CP content (205.5 g/kg DM), which was regarded as a great protein source for small ruminants to surpass the minimum protein source for better performance [3]. Forage tree legume, such as Leucaena, is commonly used in ruminant nutrition, due to its quality for providing a high content of CP, which varies between 17 and 30 %, depending on the variety, plant parts, and season [22]. Although the NDF and ADF contents in leucaena are in the range of 34.00 - 42.00 and 18.50 - 26.50 %, respectively, it is indicated as good quality roughage for ruminants [23,24]. Since hemicellulose (derived from the difference between NDF and ADF contents [25]) is the most complex of plant polysaccharides, its digestibility is closely associated with lignin, possibly causing a low ruminal rate of passage and a low availability of protein and energy for animal performance [26].

CP content in Pangola hay was kept under the minimal range (around 7 %) needed for normal requirements of ruminal protein levels for cellulolytic bacterial activity [27]. Meal concentrate, containing DM, CP, NDF, ADF, and GE of 908.1, 145.7, 322.9, 132.6 g/kg DM and 3,377.24 cal/g DM, respectively, was supplemented to provide protein and energy to meet animal requirement for better growth and fattening performance [3].

Intake, Average daily gain, and body weight

Pre-restriction Period

Since goats in all treatments during the pre-restriction period had been offered the same quality of Pangola hay and meal concentrate, there were no significant differences among total dry matter intake, total dry matter to body weight (%BW), DM intakes of protein, NDF, or ADF (**Table 2**). Total daily dry matter intake in all treatments increased from 663.63 to 682.41 g DM (**Figure 1**). However, total dry matter intake to body weight (%BW) among treatments (3.28, 3.39 and 3.21 %BW, respectively), were in the normal standard [28,3].

Animals at different initial weight of 18.13, 17.49, and 17.95 kg showed different total dry matter intakes of 663.63, 682.41, and 667.89 g DM/h/d for Treatments 1, 2, and 3, respectively, where the ratio between roughage and concentrate ingested by animals was 26:74; 29:71; 28:72 % for Treatments 1, 2, and 3, respectively. High amounts of meal concentrate would decrease ruminal gut fill, causing lower intake of hay [26]. As a result, the high amount of meal concentrate (pellet and enriched with high protein and energy contents) supplemented to the animals in the pre-restriction period resulted in a better daily growth rate of 102.38 - 136.90 g (**Table 3**) [3,29]. Moreover, meal concentrate as pellet would increase feed consumption and performance when large amounts of hay were fed [30], due to faster intake rate and less feed irritation from dust [31].

Restriction Period

There were significant differences among total dry matter intake, total dry matter to body weight (%BW), DM intakes of protein, NDF, and ADF ($P < 0.05$; **Table 2**). During this period, the animals in Treatments 2 and 3 were fed only Pangola hay at a limited amount to induce weight loss according to the particular treatments, where lower feed intake on the low energy ration as hay would indicate a greater effect on feed intake and, hence, on lower protein intake [32]. Consequently, goats in Treatments 2 and 3 had total dry matter intake of 352.36 and 218.22 g DM/day, respectively, which were indicated as lower maintenance of 47.5 and 67.5 % [3]. It can be pointed out that lower dry matter intake tended to be static in Treatments 2 and 3 in the period of restriction, while the trend of dry matter intake of 703.49 g DM was increasing in Treatment 1 as the control group (**Figure 1**).

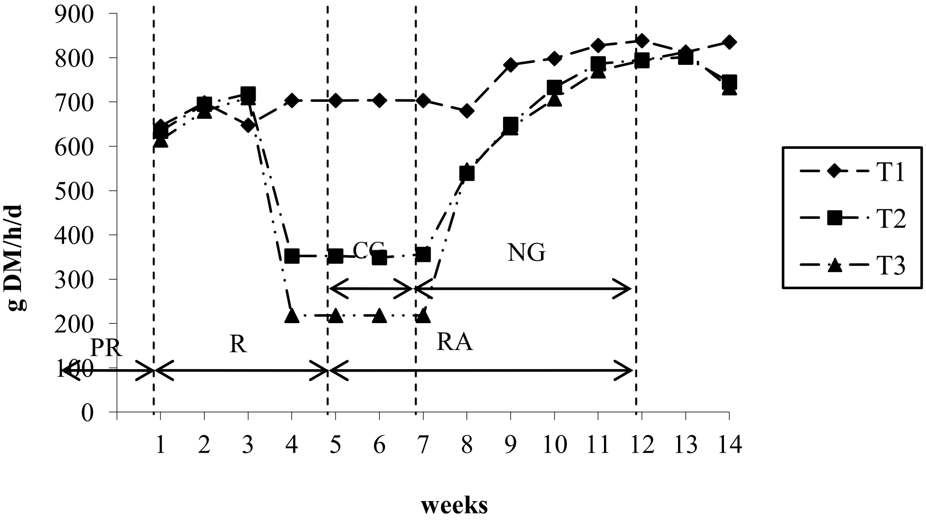

Figure 1 Dry matter intake among animals in all feeding regimes.
PR = Pre-restriction; R = Restriction; RA = Re-alimentation; CG = Compensatory growth; NG = Normal growth.

Daily protein intakes in the restriction feeding period were 83.30, 18.19, and 11.26 g DM for Treatments 1, 2 and 3, respectively (**Table 2**). Lower protein intakes in Treatments 2 and 3 would have had an effect on weight loss according to the feeding regimes (**Table 3**) [29]. The animals in Treatment 1 as the control could maintain average daily gains of 100 g/d (*i.e.* 134.37 g/h/d), while the average weekly and daily gains of the restricted Treatments 2 and 3 decreased in the restricted period of feeding (**Table 3**). In spite of the fact that the final weight was not significantly different among treatments, orthogonal contrasts detected that treatment effects responded linearly ($P < 0.05$). This present study was similar to another study on the impact of feed restriction on sheep; this consistency was related to the level of feed restriction [33]. Apparently, we attempted to provoke the compensatory response by weight deprivation in the re-alimentation period.

Re-alimentation Period

During this period, the animals in Treatment 1 were still offered the same feeding regime (Pangola hay supplemented with meal concentrate) as in the first and second period, while dried leucaena was offered *ad lib* as the sole diet to the animals in Treatments 2 and 3. From health observations on animals in both treatments, there was no incidence of leucaena toxicity, as hair loss, profuse salivation, listlessness, or appetite loss [2,34,43], shown during the study. As leucaena was fed to the animals, there was no adverse effect of toxicity from mimosine, due to the ruminal *Synergistes jonesii,* the mimosine derivatives as 3-hydroxy-4(1H)-pyridone (DHP) degrading bacteria, naturally found in the Thai crossbred goats [34].

The control animals in Treatment 1 had increased total feed intake (796.54 g DM/day) due to their bodyweight and also to maintain their ADG of 115 g/day, as summarized in **Tables 2** and **3**. Meanwhile, goats in Treatments 2 and 3 received only Leucaena, with total feed intake of 721.31 and 714.94 g DM/day, respectively. The intakes gradually increased, as shown in **Figure 1**. Feeding good quality leucaena allowed greater total dry matter to %BW ($P < 0.024$, **Table 2**) during the re-alimentation period, which is the major mechanism responsible for compensatory growth. In particular, greater protein intake in Treatments 2 and 3 were highly significant (**Table 2**). As a result, rapid fermentation of forage into fine particles led to the escalation of flow rate and minimized rumen function [35]. When leucaena was fed alone, voluntary intakes were reported to be low to moderate (1.7 - 2.7 % DM intake (DMI) as a percentage of body weight). Intake was also variable, depending on the other dietary components with which the leucaena was fed [23]. It was noted that the NDF intake of leucaena in Treatments 2 and 3 was lower than that in Treatment 1 (control), but higher ADF intake was found in Treatments 2 and 3.

Table 3 Effect of weight changes among animals during the 3 feeding regimes.

Items	**Treatments**			**SEM**	**P-value**	**Orthogonal contrast**
	T1 (C)	**T2 (M)**	**T3 (S)**			**T1 vs. T2,T3**
1. Pre-restriction Period						
Number of animal (h)	3*	4	4			
Feeding Period (week)	3	3	3			
Initial weight (Kg)	18.13	17.49	17.95	0.53	0.902	0.766
Final weight (Kg)	20.28	20.20	20.82	0.65	0.923	0.887
Total live weight gain (Kg/h)	2.15	2.71	2.87	0.23	0.502	0.268
Average weekly gain (g/h)	716.67	904.16	958.33	78.20	0.502	0.268
Total Average daily gain (g/h)	102.38	129.16	136.90	11.17	0.503	0.268
2. Restriction Period						
Number of animal (h)	4	4	4			
Feeding Period (week)	4	4	4			
Initial weight (Kg)	20.34	20.52	20.58	0.80	0.994	0.915
Final weight (Kg)	24.11	20.16	18.33	1.12	0.086	0.038
Total live weight gain (Kg/h)	3.76[a]	-0.36[b]	-2.25[c]	0.77	< 0.001	< 0.001
Average weekly gain (g/h)	940.62[a]	-90.00[b]	-562.50[c]	192.89	< 0.001	< 0.001
Total Average daily gain (g/h)	134.37[a]	-12.85[b]	-80.35[c]	27.56	< 0.001	< 0.001
3. Re-alimentation Period						
Number of animal (h)	4	4	4			
Feeding Period (week)	7	7	7			
Initial weight (Kg)	25.42[a]	19.00[b]	18.56[b]	1.25	0.023	0.007
Final weight (Kg)	31.05[a]	23.12[b]	23.04[b]	1.49	0.020	0.006
Total live weight gain (Kg/h)	5.63	4.12	4.47	0.37	0.227	0.101
Average weekly gain (g/h)	805.00	588.92	638.92	52.53	0.227	0.101
Total Average daily gain (g/h)	115.00	84.13	91.27	7.50	0.227	0.101
3.1 Compensatory growth						
Feeding Period (week)	2	2	2			
Average daily gain (g/h)	106.79	141.25	158.57	16.98	0.491	0.271
3.2 Normal growth						
Feeding Period (week)	5	5	5			
Average daily gain (g/h)	118.29[a]	61.29[b]	64.36[b]	9.43	0.004	0.001

Means in the same row with different lowercase superscripts are significantly different ($P < 0.05$).
*One animal missing due to illness and recovery in the following periods.

In **Table 1**, the protein and energy contents in leucaena were close to those in meal concentrate, which would contribute to increased protein content and energy for better growth performance. However, leucaena itself contains more cell wall content as NDF and ADF. As leucaena is considered a good protein forage supplement, there is a disadvantage from hemicellulose derived from the difference between NDF and ADF contents [25]. Since hemicellulose is the most complex of plant polysaccharides, its digestibility is closely associated with lignin mostly found in ADF content, possibly causing low ruminal rate of passage and low availability of protein and energy for animal performance [26]. However, more ADF intake from leucaena in Treatments 2 and 3 would have a detrimental effect on rumen digestion, due to the slow rate of passage of roughage in the rumen, possibly causing lower growth performance [28,36].

It is interesting to note that ADG in the restricted animals during the first 2 weeks of re-alimentation increased to 141.25 and 158.57 g in Treatments 2 and 3, respectively (**Table 3**, **Figure 2**). Dry matter intake increased linearly ($P < 0.05$), with increased leucaena, although it was not altered significantly in the first 2 weeks of re-alimentation. The base energy metabolism continued to increase slowly adjusting to the new feeding regime and so the utilization of energy and protein remains to be more efficient while the energy requirements for growth remain the same, as a result of compensatory growth [33]. The intakes in the first 2 weeks of re-alimentation were 594.31 and 594.38 for Treatments 2 and 3, respectively. Subsequently, this result can be considered as compensatory growth during the re-alimentation period. Research in beef steers shows that fasted steers refed the hay diet could obtain optimum rumen fermentative capacities between d 7 and 14 of re-alimentation [37]. Furthermore, the alterations of hormones during early re-alimentation was associated with metabolic changes and might have been indicated as signal effects for the initiation of development processes and compensatory growth [38]. In the subsequent 5 weeks during the re-alimentation period, the ADG were at 106.79, 61.29, and 64.36 in Treatments 1, 2, and 3, respectively. The ADG in Treatments 2 and 3 were lower than in a previous study by about 80 - 90 g, due to differences in the nutritional value of leucaena provided [6]. ADF content in dried leucaena in the present study was higher than the previous study by 18.23 % [6]. Meanwhile, the intakes in the following 5 weeks were 772.11 and 763.17 for Treatments 2 and 3, respectively. This is possibly due to the ADF content in leucaena affecting lower digestibility [24].

Average daily gain in the control animals in Treatment 1 was still over 100 g at 115 g during the re-alimentation period, while the single feeding of leucaena resulted in a total ADG of 84.13 g/d and 91.27 g/d in Treatments 2 and 3, respectively (**Table 3**). A similar result was observed where single feeding of leucaena to goats resulted in ADG of 82.08 g, achieved within 60 days period of feeding [6]. Meanwhile, Bali bulls fed close to 100 % diet of leucaena achieved ADG of 560 - 610 g/d [39]. Potential feeding of leucaena in the previous and present studies may be attributed to the higher dry matter intake and quality of diet. Single feeding of leucaena can achieve supreme results of ADG, instead of the control animal, in short period of re-alimentation (2 weeks).

Considering the total ADG throughout the whole study, the goats in Treatments 2 and 3 had lower overall weight gains than the normal growth in Treatment 1 (4.12 and 4.47 vs 5.63 kg, respectively). Re-alimentation periods of 49 days with *ad libitum* leucaena feeding in this study did not allow full compensation of weight loss. Animal needs to extend compensatory growth because of several reasons, for instance, the level of restriction and the quality of feed during re-alimentation [40]. Intake of single leucaena feed without concentrate supplementation may have reduced the effect of nutrient intake on energy used for the performance during the consequent period of re-alimentation [33]. During the re-alimentation, compensation varied among different body dimensions, which indicated that the priority of nutrients used by different parts of the body had been changed during the restriction and consequent re-alimentation periods [41]. Inhibition of an animal's growth rate may result in permanent stunting, even if they were given by good nutritive diet [30,42].

Furthermore, the possible condensed tannins in leucaena would form a complex with protein that is resistant to microbial degradation in the rumen, but soluble in the acid medium in the small intestine [43]. This can increase animal production without any effect on feed intake. Condensed tannins when ingested in moderate amounts usually have positive effects, and do not reduce intake. The high level of leucaena supplementation generally did not enhance ADG, perhaps in part because of the opposite effects on forage ADF intake [36]. The objective of this study was for continuous growth of the animal, from losing body weight in restriction feeding and subsequent attaining of body weight as desired. The enormity of compensation in cattle is equal to the degree of previous growth restriction. Consequently, a lower nutritional diet from Pangola hay during restriction periods affect maintenance energy requirements or efficiency of energy utilization [44]. It was, therefore, concluded that the composition of the diets, the periods of restriction and re-alimentation, the variable age, and the duration of the onset of restriction had a bearing on the results of the study [44].

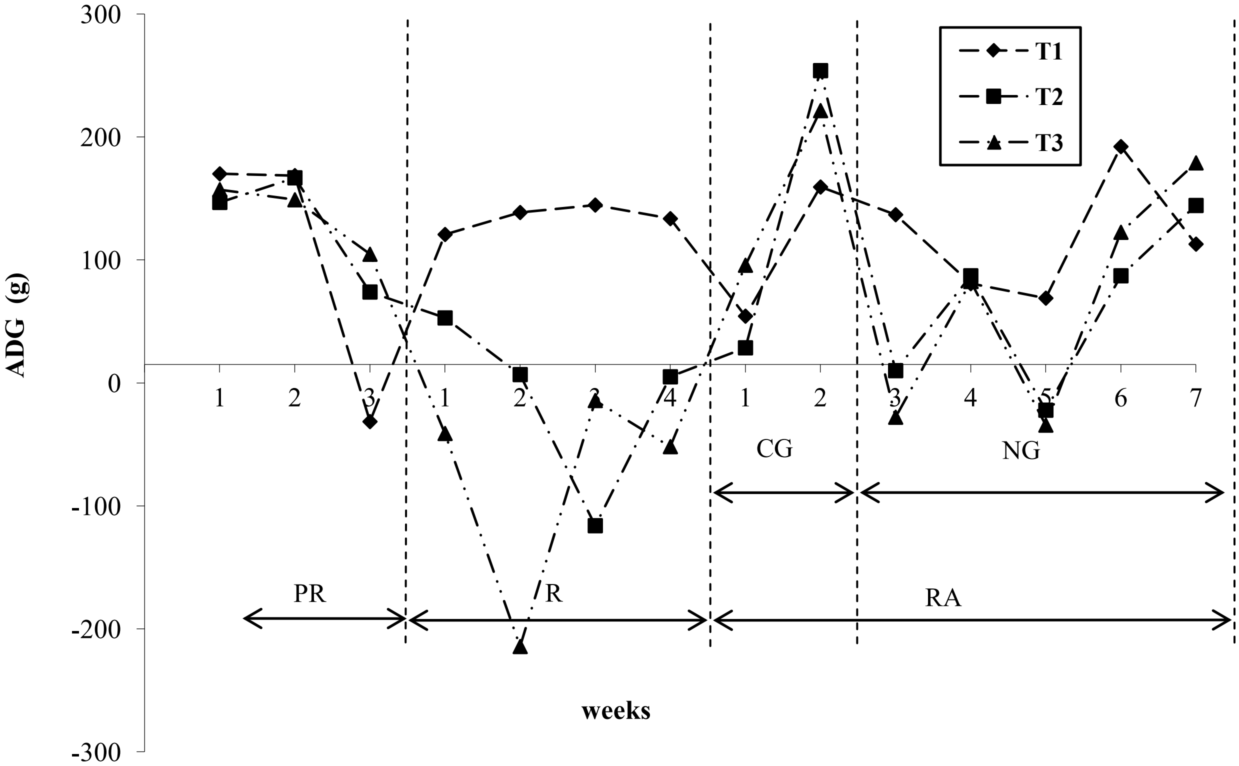

Figure 2 Animal ADGs in all feeding periods.
PR = Pre-restriction; R = Restriction; RA = Re-alimentation; CG = Compensatory growth; NG = Normal growth.

Conclusions

Forage tree legume, such as leucaena, has high CP content, but the disadvantage of high NDF and ADF contents would lower ruminal availability of protein and energy for animal performance. It can be concluded that the potential of single leucaena feeding for compensatory growth was expressed in a short period of 2 weeks after re-alimentation. Consequently, the total ADG of the restricted animals during the period of re-alimentation obtained the minimum ADG of 84 - 91 g which was suggested to achieve the overall ADG close to the normal growth.

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