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Original Article

Effects of dietary crude protein levels on nutrient digestibility and growth performance of Thai indigenous male goats

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Abstract

The experiment was conducted to evaluate the growth performance of Thai indigenous male goats fed different levels of crude protein (CP) in total mixed rations (TMR). Twenty goats, average body weight of 15.84±2.35 kg were used. The four dietary treatments were randomly allocated into 5 blocks of the animals stratified on their initial body weight. Dietary treatments contained 8, 10, 12 and 14% CP (% of DM) with a concentrate: roughage ratio of 85: 15. The feeding trial lasted for 120 days. At the end of feeding trial, digestion trial was conducted by total collection method for a 7-day period. Increasing levels of CP contents (8, 10, 12 and 14%) significantly lead to increasing amount of crude protein intake (CPI), from 47.00 to 84.81 g/d and digestible crude protein intake, from 2.89 to 6.28 g/$BW^{0.75}$/d ($p<0.05$). Increasing CP levels in TMR resulted in linearly increased goat's final body weight (23.10, 23.42, 24.10 and 27.42 kg, respectively), weight gain (6.84, 7.37, 7.60 and 11.06 kg, respectively) and average daily gain (ADG) (56.97, 61.42, 63.30 and 92.13 g/d, respectively) ($p<0.01$). Crude protein digestibility (62.05, 67.39, 71.23 and 74.89%, respectively) was increased linearly ($p<0.05$) with increasing levels of CP levels in TMR. The results of the regression of CPI (g/$BW^{0.75}$/d) on ADG (g/$BW^{0.75}$/d) showed that the goats needed 3.57 g/$BW^{0.75}$/d to maintain their body weight. The estimation of CP requirement for goat BW gain (g/g gain) was 0.49. It can be concluded that increasing levels of CP content in TMR not only improved CPI but also enhanced CP digestibility and promoted growth performance of Thai indigenous goats. According to Thai indigenous goat response linearly to levels of CP in TMR so that more research study is needed to evaluate whether feeding greater levels CP would improve the growth performance.

Keywords: crude protein, growth performance, nutrient digestibility, Thai indigenous goat

1. Introduction

In many tropical areas, goats are a major source of income for farmers (Wilson *et al.*, 1980). In Thailand, Saithanoo *et al.* (1993) reported that most of the Thai's goat numbers are in the southern regions. These animals are exclusively raised for meat by Thai Muslim in mixed small-scale farms; they represent a major source of income for this group (Pralomkarn *et al.*, 1995). The performance of Thai indigenous goats is generally lower than that of crossbred goats under optimum management conditions (Kochapakdee *et al.*, 1995). Pralomkarn *et al.* (1993) found that Thai

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indigenous goats raised under good management had significantly higher percentages of carcass fat, but lower percentages of muscle when compared to goats raised under poor management systems in villages.

Thai indigenous goats, as in many tropical countries, are commonly raised in free-range systems and the feeding is based on native grasses or forage, which often have low nutritive values. These animals are given little or no energy and protein supplements. The local breed has a small body size. Kochapakdee *et al.* (1994) reported that the average mature weight at the age of 18-24 months is 24 kg for females. Studies on this goat type given different diets showed growth rates from 20 to 100 g/d (Pralomkarn *et al.*, 1993; Saithanoo *et al.*, 1993; Kochapakdee *et al.*, 1994; Kochapakdee *et al.*, 1995 and Pralomkarn *et al.*, 1995).

The objectives of the present study were (1) to investigate the effect of feeding diets that contained different levels of crude protein (CP) on growth performance of Thai indigenous male goats and (2) to determine the protein requirement for maintenance and growth performance.

2. Materials and Methods

All procedures associating with the animal managements in the present study were approved by the Ethical Principles for the Use of Animals for Scientific Purposes of the National Research Council of Thailand.

2.1 Location and climate data

The study was conducted at the Chumporn Animal Nutrition Development Station, Tha Sae District, Chumporn Province, Thailand. Overall, the weather during the experimental period showed a 23-31°C temperature range, 41% of relative humidity, and 968 mm of precipitation.

2.2 Animal management

Twenty male goats, approximately 8-12 months of age, with an average body weight (BW) of 15.84±2.35 kg were randomly selected from private herds. All goats were vaccinated against foot and mount disease and hemorrhagic septicemia. Vitamins A, D_3, E, and anti-internal and external worm were injected to ensure the vitamin sufficiency and a worm free condition, respectively, before the experiment started. The animals were kept in individual cages of 1×1.5 m.

2.3 Experimental plan

Randomized complete block design with 5 blocks was used to their initial body weight. Dietary treatments were the different levels of CP content in total mixed rations (TMR), which were 8, 10, 12, and 14% CP (% of DM). The feeding trial lasted for 120 days. After the end of the feeding trial, the digestibility of the feed was determined by the total collection method over a 7 day-period.

2.4 Feed and feeding

Feed ingredients and chemical composition of experimental diets are presented in Table 1. Pangola grass (*Digitaria eriantha*) hay was chopped into a size of approximately 2 mm before incorporating into TMR. Diets were weighted daily and offered to the animal at 08.00, 12.00, 16.00, and 20.00 hrs in equal portions. Feed refusals were measured and sampled daily at 07.30 hrs on the next day. Clean water was freely available for ad libitum consumption.

2.5 Digestibility trial

After the end of the feeding trial, all animals were used for a digestibility trial that was conducted using total collection method for a 7-day period. Feeds, feed refusals, and feces were weighted and then 10% of feed refusals and feces were sub-sampled each day. Composites of feeds, feed refusals, and feces were sub-sampled approximately 500 g from each goat. Samples were dried at 65°C for 72 hrs and ground to pass a 1 mm screen using Wiley mill. The samples were stored at -21°C pending further chemical analysis.

2.6 Chemical analysis

Proximate chemical composition of feeds, feed refusals, and feces samples as well as calcium and phosphorus contents of feeds were analyzed by a method described by AOAC (1990). Gross energy of all samples was determined using adiabatic bomb calorimeter. Metabolizable energy (ME) content of feeds was estimated using the equation of ME = 0.82 × DE as proposed by NRC (1996).

2.7 Statistics analysis

Intake, apparent nutrient digestibility of total mixed rations, and animal performance characteristics were analyzed statistically as randomized complete block design using the mixed model as described by Littell *et al.* (1996). Crude protein effects and block effects were considered as fixed and random effects, respectively. Orthogonal polynomial (linear, quadratic, and cubic effects) response of increasing levels of CP in TMR was tested. The statistical model was:

$$Y_{ijk} = \mu + \beta_i + \tau_j + \varepsilon_{ijk}$$

Where Y_{ijk} was observed variable, μ was the overall mean, β_i was the random effect of the i^{th} block, τ_j was the fixed effect of the j^{th} treatment (CP levels), and ε_{ijk} was the residual error. Estimation of crude protein requirements for maintenance and growth of goats using simple linear regression as previously described by Paul *et al.* (2003) and Solis *et al.* (1991). Relationship between crude protein intake (CPI, g/metabolic

Table 1. Feed ingredients and chemical composition of experimental diet.

	Treatment diets			
	8	10	12	14
Ingredients				
Cassava chip	55.5	51.5	47.5	44.0
Palm kernel cake	24.0	23.5	22.8	21.5
Soy bean meal	3.0	7.5	12.2	17.0
Pangola grass hay	15.0	15.0	15.0	15.0
Dicalcium phosphate	1.0	1.0	1.0	1.0
Salt	1.0	1.0	1.0	1.0
Premix[1]	0.5	0.5	0.5	0.5
Chemical composition				
DM (%)	87.40	87.75	88.56	87.92
OM (%DM)	91.79	92.37	91.98	92.31
CP (%DM)	8.30	10.36	12.90	14.11
EE (%DM)	0.49	0.46	0.45	0.47
CF (%DM)	14.17	13.93	13.70	13.88
Ash (%DM)	8.21	7.63	8.02	7.69
GE (Mcal/kgDM)	4.03	4.08	4.13	4.08
Ca (%DM)	0.57	0.52	0.56	0.52
P (%DM)	0.27	0.29	0.34	0.31

[1]a kg contains vitamins A, D3 and E of 2,160,000, 400,000, and 2,700 IU, respectively, and Mn 8.5 g, Zn 6.4 g, Fe 8.0 g, Cu 1.6 g, Mg 16 g, Co 320 mg, I 800 mg, and Se 32 mg.

body size ($BW^{0.75}$)/d) and average daily gain (ADG, g/$BW^{0.75}$/d) was analyzed. The compound symmetry (CS) of covariance component was used as its lowest AIC values (Littell *et al.*, 1996). The statistical model was:

$$Y = a + bX,$$

where Y was CPI (g/$BW^{0.75}$/d) and X was ADG (g/$BW^{0.75}$/d), while 'a' was y-intercept and 'b' was the slope of the equation.

3. Results and Discussion

3.1 Chemical composition of experimental total mixed rations

All experimental diets provided a similar amount of DM, OM, EE, CF, Ash, and GE to all treatments (Table 1). As expected, crude protein contents of dietary treatments varied with treatment. In this study, the diet component was placed to the level at 85: 15 of concentrate: forage ratio in accordance with the reports of Haddad (2005), who found that this ratio significantly improved feed utilization by goats.

3.2 Intake and growth performance of the animals

Intake and growth performance characteristics of Thai indigenous goats are presented in Table 2. Estimated metabolizable energy intake in any treatment group showed that there was no energy limitation according to the report of AFRC (1998) that ME requirement for maintenance of goat derived from feeding trial was 438 kJ/$BW^{0.75}$/d (approximately 105 kcal/$BW^{0.75}$/d). This indicated that there was no detrimental effect of energy deficiency. Dry matter (DMI) and energy intake (i.e. gross energy, digestible energy, and metabolizable energy) did not significantly respond ($p>0.05$) to the levels of CP in TMR. The result of this study was consistent to the report of Prieto el al. (2000), who found that there was no effect of different levels of CP in diets on DMI of either Boer-Spanish crossbred or Spanish kids. This was, however, in contrast to the report of Negesse *et al.* (2001), who found that there were significant effects from increasing levels of CP in diet on increased levels of DMI. It is possible that the difference in feed ingredients and animal breed resulted to this dissimilarity.

As expected, increased levels of CP in TMR resulted in significant increased CPI and digestible crude protein intake (DCPI) of the animals. Increasing CP levels in TMR (8, 10, 12, and 14%) led to a linearly increased goat's final body weight, weight gain, and average daily gain (ADG) ($p<0.01$). Growth performances of Thai indigenous goats from this study are consistent with the performance of goats reported by Negesse *et al.* (2001), who reported that Saanen kids fed the minimum dietary CP levels had lowest ADG and

Table 2. Least square means of intake and growth characteristics of goats fed different levels of crude protein diet.

	Treatment diets				SEM	Contrast[1]		
	8	10	12	14		L	Q	C
Initial BW (kg)	15.63	15.49	15.87	15.73	0.43	-	-	-
Final BW (kg)	23.10	23.42	24.10	27.42	1.06	<0.01	0.09	0.55
Weight gain (kg)	6.84	7.37	7.60	11.06	0.79	<0.01	0.06	0.28
Average daily gain								
g/d	56.97	61.42	63.30	92.13	6.56	<0.01	0.06	0.28
$g/BW^{0.75}/d$	5.85	6.44	6.58	9.03	0.58	<0.01	0.10	0.27
Intake								
Dry matter								
g/d	563.41	567.31	562.76	603.30	21.69	0.12	0.28	0.47
$g/BW^{0.75}/d$	61.07	61.26	61.02	61.41	0.65	0.72	0.84	0.64
Crude protein								
g/d	47.00	59.31	72.40	84.81	3.72	<0.01	0.98	0.91
$g/BW^{0.75}/d$	5.09	6.37	7.87	8.66	0.11	<0.01	0.01	0.03
Digestible protein								
$g/ BW^{0.75}/d$	2.89	4.07	5.37	6.28	0.29	<0.01	0.60	0.67
Gross energy								
Kcal/d	2270	2315	2321	2461	84.77	0.06	0.48	0.58
$Kcal/ BW^{0.75}/d$	246.12	249.93	251.99	250.51	2.65	0.10	0.19	0.84
Digestible energy								
$Kcal/ BW^{0.75}/d$	178.05	187.41	186.85	188.55	7.22	0.27	0.55	0.68
Metabolizable energy								
$Kcal/ BW^{0.75}/d$	146.00	153.68	153.22	154.62	5.92	0.27	0.55	0.68

[1]L = linear, Q = quadratic and C = cubic effects.

Table 3. Least square means of nutrient digestibility (%) of different levels of crude protein in total mixed rations.

	Treatment diets				SEM	Contrast[1]		
	8	10	12	14		L	Q	C
Nutrient digestibility								
Dry matter	76.08	78.89	77.06	78.13	2.43	0.64	0.68	0.44
Crude protein	62.05	67.39	71.23	74.89	2.71	<0.01	0.72	0.90
Organic matter	79.45	81.56	80.90	82.18	2.09	0.35	0.75	0.49
Energy utilization								
Digestible energy	75.83	78.39	77.60	78.40	2.38	0.45	0.68	0.62
Metabolizable energy	62.18	64.26	63.64	64.29	1.95	0.45	0.68	0.61

[1]L = linear, Q = quadratic and C = cubic effects.

the ADG significantly increased when the kids fed diets with higher levels of CP diets. Furthermore, Pralomkarn *et al.* (1995) reported that both Thai indigenous and crossbred kids received more CP resulted in higher growth rates. Similarly, Intharak and Saelim (2008) found that the significant responses of final body weight, weight gain, and ADG of Thai indigenous × Anglo-Nubian crossbred to increasing levels of dietary CP were in a linear fashion. This finding indicated that Thai indigenous goat responded well to the amount of CP intake.

3.3 Nutrient digestibility

Apparent nutrient digestibility of dietary treatments in Thai indigenous goats is shown in Table 3. The results indicated that there was no significant effect ($p>0.05$) of different levels of CP in TMR on apparent nutrient digestibility except CP digestibility. Crude protein digestibility linearly increased ($p<0.05$) in accordance with increasing levels of CP in TMR. Our finding was consistence with the report of Pralomkarn *et al.* (1995). These authors found that goats fed

with diet ad libitum (54.2 g/$BW^{0.75}$/d, DMI) had CP digestibility of 80.8% and the CP digestibility was significantly decreased when the goats were fed with a lower amount of feed or CP.

3.4 Estimation of crude protein requirement for maintenance and weight gain

A long-term feeding trial is a technique for the estimation of the nutrient requirements for maintenance and growth of animals as proposed by NRC (1996) and AFRC (1998). The result of simple linear regression analysis between CPI (g/$BW^{0.75}$/d) and ADG (g/$BW^{0.75}$/d) showed that the y-intercept of equation was 3.57 with standard error (SE) of 1.12; the t-value indicated that it differed from zero ($p<0.05$). Therefore, it should be confidentially reported that Thai indigenous goats needed 3.57 g/$BW^{0.75}$/d to maintain their body weight, at zero weight gain. Furthermore, the slope of this equation was 0.49 with SE of 0.15 (equation I); the t-value also indicated that this value differed from zero ($p<0.05$). Thus, the estimation of the crude protein requirement for BW gain (g/g gain) of Thai indigenous goats was 0.49. The simple linear regression was:

$$Y = 3.57\ (\pm 1.12) + 0.49\ (\pm 0.15)\ X,\ p<0.05 \qquad (I)$$

Given the body weight of goat was 20 kg and the animal growth rate was 100 g/d, and using our information, 83 g/d of crude protein were required for feeding the goat. The CP requirement from our finding were slightly higher than that of 70 g/d of Kearl (1982), 68 g/d of ICAR (1998), and 76 g/d of NRC (1981), however, it was lower than the report of 100 g/d of Mandal et al. (2005). Nutrient requirements depend upon animal genotype, environmental condition, and dietary situation, as well as the calculation method (NRC, 1981; AFRC, 1998 and Mandal *et al.*, 2005).

4. Conclusion

The results of the present study indicated that Thai indigenous goat's growth performance responded significantly to CP levels in TMR by linear fashion. Increasing levels of CP content in TMR not only improved the CP intake but also enhanced the CP digestibility and promoted growth rate of Thai indigenous goats. Additionally, the estimation of CP requirements for maintenance and growth of this type of goats were 3.57 (±1.12) g/$BW^{0.75}$/d and 0.49 (±0.15) g/g gain, respectively.

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