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The Effects of Dietary Crude Protein Levels on Nutrient Digestibility, Nitrogen Retention, Rumen Environment and Microbial Nitrogen Synthesis of Growing Female Bach Thao Goats in Vietnam

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Abstract: An experiment was carried out to evaluate the effects of crude protein (CP) contents on feed intake, nutrient digestibility, rumen parameters and estimated nitrogen synthesis of Bach Thao goats. Five female goats from 4-5 months of age (16.7±0.92 kg) were used for this experiment in a Latin square design. Five treatments were applied, containing dietary CP contents of 5.0, 5.5, 6.0, 6.5 or 7.0 g/kgLW/day. The results showed that dry matter (DM), Neutral detergent fiber (NDF) and acid detergent fiber (ADF) intakes and digestibilities were not significantly different among the treatments ($P > 0.05$), and the rumen parameters were also similar in different treatments. However, the nitrogen retention was significantly different ($P < 0.05$) among the treatments and it was higher for the treatments of 6.0, 6.5 and 7.0 gCP/kgLW. The purine derivatives and estimated microbial nitrogen synthesis were numerically higher for the treatments containing 6.0, 6.5 and 7.0 gCP/kgLW. Although there was a gradual increase of daily weight gain by increasing the amount of dietary CP from 5.0 to 7.0 gCP, no significant difference was found. Based on the results, the dietary CP from 6.0 to 6.5 g/kgLW for growing Bach Thao goats is recommended.

Key words: dairy goat, keeping, nutrition, production improvement, growth

1. Introduction

In Vietnam dairy goats have been recently raised in both small households and industries, and Bach Thao goat breed is mainly raised for milk and meat production purpose due to its suitable adaptation to the warm climate, local feed resources and farming conditions [1]. Because of the increasing demand for and price of goat products (milk and meat) in the whole country, dairy goat production has been paid more attention by farmers and government agencies for improving the incomes, as well as avoiding serious diseases and losses. In many projects aiming to erase hunger and alleviate poverty, dairy meat goats have been used as the priority tools in Vietnam [2]. Protein is required for most normal functions of the body, including maintenance, growth, reproduction, lactation, and hair production. Dietary crude protein (CP) requirements are higher for growth, gestation, and lactation. The rumen plays a major role in breaking down consumed protein into bacterial protein through bacterial fermentation. Feeds like forages, distilled grains and meals (soybean extraction, coconut and cottonseed meals) are common sources of protein for goat rationing. The protein requirements are higher during growth and lactation. The results obtained by Negesse et al. (2001) in post weaned goat kids show

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that inadequate or excessive inclusion of CP in the diet results in inefficient use of nitrogen intake [3]. In that respect, Martínez-Marín et al. (2012) stated that we should take into account the negative effect of inadequate available nitrogen in relation to energy on ruminal digestion [4]. However, studies of dietary levels of CP for Bach Thao goat breed are limited, particularly for the growing female goats. The objective of this study was to determine the optimum levels of CP for growing Bach Thao female goats.

2. Materials and Methods

2.1 Experimental Design and Chemical Composition of Feeds

The experiments were carried out in the experimental farm of Department of Animal Husbandry, College of Agriculture and Applied biology, Can Tho University from April to Sep. 2011. Five female Bach Thao goats from4 to 5 months of age (16.7±0.92 kg) were used for this experiment in a Latin square design. Five treatments contained different levels of CP, 5.0, 5.50, 6.0, 6.5 and 7.0 g/kgLW/day corresponding to CP5.0, CP5.5, CP6.0, CP6.5 and CP7.0 treatment groups. The chemical compositions of feed, the formula of goat diets, dietary nutrients and metabolized energy are showed in Tables 1 and 2. In different dietary treatments, the CP concentrations were gradually increased from 16.0-21.4%, while dietary ME contents were similar among the treatments (Table 2).

Table 1 Chemical compositions (%DM) of feeds used in the experiment.

Feeds	Chemical composition (%)							ME (MJ/kgDM)
	DM	OM	CP	EE	NDF	ADF	Lig.	
Para grass	18.2	88.0	11.1	4.95	69.1	34.5	6.66	8.33
Sesbania grandiflora	22.7	90.5	22.6	8.66	23.6	20.5	8.22	10.1
Soybean extraction meal	86.0	88.4	43.8	1.53	34.2	16.4	6.51	12.7
Urea	-	-	287	-	-	-	-	-

DM: dry matter, OM: organic matter, CP: crude protein, EE: ether extract, NDF: neutral detergent fiber; ADF: acid detergent fiber; Lig: lignin; ME: metabolizable energy.

Table 2 Dietary formula and chemical compositions (% DM) of the Exp.

Treatments					
CP5.0		CP5.5	CP6.0	CP6.5	CP7.0
Ingredient composition, % DM					
Para grass	75.8	74.1	73.4	71.6	71.0
Sesbania grandiflora	22.8	20.6	21.7	23.8	20.7
Soybean extraction meal	0.98	4.60	3.60	2.80	6.20
Urea	0.42	0.70	1.30	1.80	2.10
Dietary chemical compositions, % DM					
Dry matter (DM)	18.7	18.9	20.0	19.6	19.5
Organic matter (OM)	88.7	88.7	88.6	88.9	88.8
Crude protein (CP)	16.0	18.4	19.1	20.4	21.9
Ether extraction (EE)	5.74	5.52	5.57	5.65	5.40
Neutral detergent fiber (NDF)	58.6	59.3	56.8	58.8	57.3
Acid detergent fiber (ADF)	30.3	30.9	29.5	28.6	29.4
ME, MJ/kg DM	8.95	8.92	8.91	8.96	8.94

CP5.0, CP5.5, CP6.0, CP6.5 and CP7.0: dietary crude protein at level of 5.0, 5.5, 6.0, 6.5 and 7.0 g/kgLW.day; ME: metabolizable energy.

2.2 Measurements Taken and Analysis

Feeds and refusals were daily measured for analyses of DM, OM, CP, EE, NDF, ADF and ash following procedure of AOAC (1990) [5] and Van Soest et al. (1991) [6]. The metabolic energy (ME) was determined according to Bruinenberg et al. (2002) [7]. Rumen fluid was collected for determination of pH, total volatile fatty acids (VFA) and ammonia. Samples were taken at 0 h (before feeding) and 3 h after feeding in the morning on the last day of each period using a stomach tube.

Daily feed intakes, weight gain, and feed conversion ratios were measured and calculated. Apparent DM, OM, CP, EE, NDF and ADF digestibility were employed according to McDonald et al. (2002) [8].

Rumen ammonia concentration was determined by distillation and titration. Rumen VFA were determined by the procedure of Barnett and Reid (1957) [9]. The purine derivatives were determined by Allantoin and acid uric analysis [10, 11]. The supply of microbial N in gram per day was estimated following the assumptions made by Chen and Gomes (1995) [12].

2.3 Statistics Analysis

The data were analyzed by analysis of variance using the ANOVA of General Linear Model of Minitab Reference Manual Release 13.21 [13]. Then for the paired comparison of two treatments, the Tukey test was used [13].

3. Results and discussion

3.1 Feeds and Nutrients Intakes and Growth Rate

Feeds, nutrients and metabolizable energy intakes and daily weight gain of goats in different treatments are showed in Table 3.

The DM intakes of goats of CP5.0, CP5.5, CP6.0, CP6.5 and CP7.0 treatments were 641, 650, 653, 665 and 622 g/day, respectively, and there was no significant difference among the treatments ($P > 0.05$). Crude protein intakes were significantly different ($P < 0.05$) among the treatments and they were 102, 116, 125, 135, 136 g/day for CP5.0, CP5.5, CP6.0, CP6.5 and CP7.0 treatments, respectively. However, the metabolizable energy intakes were similar among the treatments. The NDF and ADF intakes were not significantly different among the treatments ($P > 0.05$). The daily weight gain (DWG) of goats gradually increased from the CP5.0 to CP7.0 treatment, however, it was not significantly different ($P > 0.05$) among the treatments. Ngo Tien Dung et al. (2005) reported that in the North Vietnam, Bach Thao goats with the live weight of 13.6 kg gave the average weight gain from 39.4 to 69.0 g/day [14]. However, results of the present study were lower than those stated by Mandal et al. (2004) being 100 g/day [15].

3.2 Apparent Nutrient Digestibility

Results presented in Table 4 indicated that the DM, OM, CP, NDF and ADF digestibilities were not significantly different among the treatments ($P > 0.50$). The DM digestibility ranged from 65.1 to 65.8%. Similarly to this study, Phengvilaysouk and Kaensombath (2006) reported the DM digestibility from 54.5 to 67.6% [16]. The CP digestibility gradually increased from the 5.0 to 7.0%, but the differences were not significant. The digestibility of NDF ranged from 62.8 to 63.9%, which was similar to those reported by Aregheore (2005) (63.9 to 69.4%) [17].

3.3 Nitrogen Balance of the Goats

The results of nitrogen balance measurement are presented in Table 5.

Daily nitrogen intakes of goats gradually increased from the CP5.0 to CP7.0 and were significantly different ($P < 0.05$) among the treatments (Table 5), while nitrogen values in feces and urine were similar ($P > 0.05$) in different treatments. The nitrogen retention (g/day) of CP6.0, CP6.5 and CP7.0 treatments were significant higher ($P < 0.05$) than other treatments. The nitrogen retention result of the present

study was in agreement with that presented by Phengvilaysouk and Kaensombath (2006) [16].

Table 3 Feeds and nutrients and metabolizable energy intakes and daily weight gain of goats in the Exp.

	Treatments					±SEM	P
	CP5.0	CP5.5	CP6.0	CP6.5	CP7.0		
Intake (g DM/day/ani.)							
DM	641	650	653	665	622	18.73	0.577
OM	568	576	578	591	552	23.79	0.579
CP	102^{a}	116^{b}	125^{b}	135^{c}	136^{c}	2.25	0.001
NDF	375	385	371	389	357	11.9	0.385
ADF	194	201	193	190	183	6.61	0.453
MEI, MJ/day/animal	5.73	5.79	5.82	5.96	5.56	0.168	0.574
Ini. live weight, kg	19.0	19.0	19.1	18.9	19.0	0.180	0.980
Final live weight, kg	19.9	20.2	20.3	20.2	20.2	0.108	0.285
Daily weight gain, g	67.2	80.0	87.4	88.2	89.4	11.3	0.625

CP5.0, CP5.5, CP6.0, CP6.5 and CP7.0: dietary crude protein at level of 5.0, 5.5, 6.0, 6.5 and 7.0 g/kgLW.day; MEI: metabolizable energy intake. ^{a,b,c} the values with the different letters in the same rows are significantly different at the level of $P \leq 0.05$.

Table 4 Apparent nutrient digestibility (%) of goats in different treatments.

	Treatments					±SEM	P
	CP5.0	CP5.5	CP6.0	CP6.5	CP7.0		
DM	65.8	65.3	65.7	65.1	65.8	1.09	0.985
OM	66.8	66.6	66.6	66.8	66.7	0.99	0.999
CP	78.8	80.2	81.2	82.1	82.3	1.32	0.362
NDF	63.9	63.1	62.8	63.9	63.1	1.96	0.992
ADF	57.6	57.6	55.8	56.5	55.3	1.99	0.887

CP5.0, CP5.5, CP6.0, CP6.5 and CP7.0: dietary crude protein at level of 5.0, 5.5, 6.0, 6.5 and 7.0 g/kgLW.day; MEI: metabolizable energy intake. ^{a,b,c} the values with the different letters in the same rows are significantly different at the level of $P \leq 0.05$.

Table 5 Nitrogen balance and retention (g/ani./day) of goats in different treatments.

	Treatments					±SEM	P
	CP5.0	CP5.5	CP6.0	CP6.5	CP7.0		
Nitrogen intake (Ni)	16.3^{a}	18.5^{b}	19.9^{b}	21.6^{c}	21.8^{c}	0.357	0.001
Nitrogen in feces	3.51	3.61	3.65	3.76	3.79	0.249	0.927
Nitrogen in urine	7.22	7.42	7.53	7.88	7.92	0.281	0.378
Nitrogen retention (Nret.)	5.57^{a}	7.50^{ab}	8.77^{c}	9.95^{c}	10.1^{c}	0.501	0.001
Nret./Ni, %	33.7^{a}	38.2^{ab}	41.5^{b}	44.3^{b}	45.6^{b}	2.08	0.010

CP5.0, CP5.5, CP6.0, CP6.5 and CP7.0: dietary crude protein at level of 5.0, 5.5, 6.0, 6.5 and 7.0 g/kgLW/day; MEI: metabolizable energy intake.

3.4 Rumen pH, NH_3-N and Total Volatile Fatty Acids (VFAs)

Rumen pH values, NH_3-N and VFAs concentrations at 0 h and 3 h after feeding of the goats were not significantly different ($P > 0.05$) among the treatments (Table 6). The pH values at 3 h after feeding were lower than those at 0 h, while the concentrations of

NH_3-N and VFAs at 3 h after feeding were higher than those at 0 h. The results indicated that there was no significant effect of increasing dietary CP on the rumen parameters in the present study. The pH values at 3 h after feeding were similar to those reported by Nguyen Van Hon (1998) (6.22 to 6.58) when goats fed Vestiver grass. Although N-NH_3 concentration at 3 h after feeding had a trend of increase by increasing dietary CP, no significant difference was found [18]. Phengvilaysouk and Kaensombath (2006) stated that NH_3-N concentration was from 27.9 to 35.7 mg/10 ml following the intakes of 6.76 to 12.3 gN per day by each goat. The total VFAs concentration at 3 h were from 111 to 113 mmol/liter, which was similar to results reported by Nguyen Van Thu (2003) (116 mmol/l) [16, 19].

3.4 Purine Derivatives Excretion and Microbial Nitrogen Synthesis

Based on the results (Table 7), Allatoin, uric acid and purine derivatives excretion in urine and MNS had a trend of gradual increase from CP5.0 to CP7.0, however there was no significant difference ($P > 0.05$) among the treatments. Allatoin and purine derivatives excretion in the present study was consisted with those presented by Belenguer et al. (2002) [20]. The estimated MNS in CP6.0, CP6.5 and CP7.0 treatments (5.18, 5.24 and 5.30 g/day, respectively) were numerically higher than CP5.0 and CP 5.5 treatments (4.03 and 4.63 g/day).

Table 6 Rumen pH, NH_3-N and total volatile fatty acids (VFAs) concentrations of goats in different treatments.

	Treatments					±SEM	P
	CP5.0	CP5.5	CP6.0	CP6.5	CP7.0		
pH at 0 h	6.81	6.75	6.87	6.92	6.86	0.049	0.204
pH at 3 h after feeding (AF)	6.55	6.63	6.65	6.67	6.65	0.036	0.195
NH_3-N at 0 h, mg/100 ml	24.2	24.2	26.6	27.0	25.9	0.991	0.167
NH_3-N at 3h AF, mg/100 ml	41.4	42.9	47.3	51.4	52.0	3.05	0.112
VFAsat 0 h, mmol/liter	84.5	83.7	85.0	82.3	84.7	2.73	0.888
VFAs ở 3 h AF, mmol/liter	113	111	113	112	111	3.97	0.996

CP5.0, CP5.5, CP6.0, CP6.5 and CP7.0: dietary crude protein at level of 5.0, 5.5, 6.0, 6.5 and 7.0 g/kgLW/day; MEI: metabolizable energy intake.

Table 7 The excretion of allatoin, uric acid and purine derivatives (mmol/ani./day) in urine and estimated microbial nitrogen synthesis (MNS) of goats in different treatments.

Criteria	Treatments					±SEM	P
	CP5.0	CP5.5	CP6.0	CP6.5	CP7.0		
Allantoin	3.05	3.41	3.93	4.28	4.31	0.417	0.247
Uric acid	1.97	2.24	2.34	2.04	2.07	0.218	0.628
Purine derivatives	5.03	5.65	6.27	6.32	6.37	0.577	0.488
MNS, g/animal/day	4.03	4.63	5.18	5.24	5.30	0.547	0.500

CP5.0, CP5.5, CP6.0, CP6.5 and CP7.0: dietary crude protein at level of 5.0, 5.5, 6.0, 6.5 and 7.0 g/kgLW/day.

Kim et al. (1999) concluded that the degree of synchrony in ruminants released energy and nitrogen likely influences the microbial protein synthesis (MPS), but only in diets containing high concentrations of readily fermentable carbohydrate where bacterial storage of intracellular polysaccharides may be limiting [21]. Therefore, MPS will be maximized by synchronizing the availability of fermentation energy and degradable nitrogen in the rumen [22]. It has been also concluded that an improved synchronization of ruminal energy and nitrogen release for MPS seems possible with some kinds of supplementations. For example, urea-molasses supplements can provide suitable nutrients for microbial growth [23]. In the

present study, there was a limitation of MNS in rumen due to some limited energy sources with increasing nitrogen in the diets.

4. Conclusion

In this study, increasing dietary CP from 5.0 to 7.0 g/kgLW/day did not affect the feed and nutrient intakes, digestibility and rumen parameters. However, the nitrogen retention was significantly higher for the CP6.0, CP6.5 and CP7.0 treatment groups. In addition, there were some numerical improvements in estimated MNS and daily weight gain for the CP6.0, CP6.5 and CP7.0 treatment groups. Based on the results of this study, the dietary CP levels of 6.0 and 6.5 gCP/kgLW/day are recommended for Bach Thao female goats.

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