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# Protein Requirements of Dorper Sheep x Small Tail Han Sheep F1 Lambs

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**Abstract:** With the development of modern sheep production, in order to effectively improve the production efficiency of sheep, according to the local natural resources and environment to implement the intensive breeding of meat sheep has become the development direction of China's sheep industry. Feed is the basis of the aquaculture industry, accounting for >70% of the cost of sheep production, at the same time, it related to the growth and development, production and reproductive performance of sheep, nutrition and feed problem is an important factor has long been plagued in development of the sheep. In this study, all the male lambs were developed normally and healthy for 3 months (Dorper Sheep x Small Tail Han Sheep F1) with an average body weight of 16.2±2.1 kg, they were randomly divided into three treatment groups (*ad libitum* feeding, 65% restricted feeding , 35% restricted feeding) all experimental sheep were fed with TMR and free access to water, single caged in metabolic cages, mainly use the digestion and metabolism trial and slaughter method to infer the protein requirement of 20-35 kg sheep lambs (Dorper Sheep x Small Tail Han Sheep F1). Through the digestion and metabolism trial and slaughter method to speculate the prediction equations of nutritional requirements about Dry Matter Intake (DMI) and Crude Protein Intake (CPI) for stall-feeding fattening of 20-35 kg sheep lambs. Total body N content and retention were determined. Growth pattern of the wool has a high influence on protein requirements of lambs. Dorper Sheep x Small Tail Han Sheep F1 growing lambs used in the study showed protein requirements for growth lower than those reported by the most nutritional systems.

**Key words:** Comparative slaughter, sheep, protein, requirement, nutrition

## INTRODUCTION

Protein was looked as the most important feed component in livestock industry, especially in ruminant. Accordingly, to clarify the protein requirements for ruminant is necessary, it can be sense and valuable to direct practical industry and ensure cultivation profitability. The NRC (2007) provided the new recommendations on nutritional requirements for sheep. However, the protein requirements for growth and maintenance was depended on many factors such as various variety, different growth environment, physiological condition and nutritional status of the animal and it widely varies among nutritional systems. (Oldham, 1987). In addition, the latest research on goats showed that protein requirements of goats also depends on feeding. Therefore, a single feeding standards of protein requirements for different treatment under the conditions of feeding is not feasible. At present, some researchers suggested that it should establish the equation of linear regression to calculate the protein requirement for maintenance and growth of ruminant. Some studies reported that it has a positive correlation between whole body protein and EBW (Empty Body Weight) with meat purpose lambs experiment (Silva *et al*., 2007).

Dorper sheep is a fast growing meat producing sheep, it is widely used as a sire around the world in meat purpose lambs production systems. Small Tail Han sheep is an excellent local sheep breed in China, Small Tail Han sheep has significant characteristics of high prolificacy. The objective of this study was to determine the protein requirements for maintenance and growth of Dorper Sheep x Small Tail Han sheep F1 growing lambs using the comparative slaughter technique and establish the equation of linear regression to estimate protein requirement with BW gain in growing sheep.

## MATERIALS AND METHODS

This 76 days experiment was conducted form June 18, 2010 to September 2, 2010 at the Taigu Wan Rongchang sheep farming professional cooperatives of Shanxi province in China (37.42 E, 112.53 N in China), the average temperature was 28.6±1.2°C. All the lambs were provided by the Shanxi Agricultural University the Youyu meat

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sheep breeding base and the lambs were male for 3 months (Dorper Sheep x Small Tail Han Sheep F1) with an average body weight of 16.2±2.1 kg.

**Diets for experiment:** Table 1 shows the composition of the complete diet for the experiment which was formulated to meet or exceed all nutrition requirement for ovis aries (AFRC, 1998; NRC, 2007). The experiment total mixed diet diet included corn gain, soybean meal, palm meal, wheat bran, corn straw powder, peanut vine powder, limestone and mineral supplement. During the trial, the lambs were fed once daily (8 am) in individual hopper and with free access to water. Diet samples were dried at 65°C for 72 h and ground through a 1 mm screen using a pulverizer for analysed. The analysis for feed ingredients included protine, fat, OM, DM, NDF, ADF, Ca and P.

**Analyzed values except metabolizable energy Comparative slaughter trial:** The lambs were placed into individual stalls (1.5 $m^2$) which have the feeder equipment and water source and all the lambs were treated for internal parasites. Selected 6 lambs as baseline group (18.00±1.4 kg) were slaughtered after 10 days at the beginning of the experimental management and diet adaptation period. The left 24 lambs were randomly divided into 3 treatments: *ad libitum* feeding (n = 12): control group, TMR complete diet and freedom drinking water. About 35% of *ad libitum* feeding (n = 6), this leve in order to maintain the lams for 0 g $day^{-1}$ weight increas: 35% of TMR complete diet and freedom drinking water.

Table 1: Ingredients and chemical composition of the experimental diet

| Items | Ingredient (%) |
|---|---|
| Cracked corn | 15.00 |
| Soybean meal | 11.00 |
| Palm meal | 10.00 |
| Wheat bran | 3.00 |
| Corn stalk | 30.58 |
| Peanut vine powder | 25.00 |
| Trace mineral mix[1] | 0.35 |
| Salt | 0.50 |
| Calcium phosphate | 0.18 |
| Saleratus | 0.18 |
| Limestone | 0.38 |
| **Chemical composition** | |
| Metabolizable energy (MJ $kg^{-1}$ DM) | 10.08 |
| Crude protein | 11.80 |
| Ether extract | 2.27 |
| Dry matter | 88.40 |
| Organic matter | 87.10 |
| Acid detergent fiber | 37.66 |
| Neutral detergent fiber | 61.35 |
| Calcium | 0.70 |
| Phosphorus | 0.40 |

[1]Provided per kilogram of the early gestation diet: 25 mg of Zn as $ZnSO_4.7H_2O$; 15 mg of Mn as $MnSO_4.H_2O$; 0.5 mg of I as KI; 0.2 mg of Co as $CoCl_2.6H_2O$; 30 mg of Fe as $FeSO_4.7H_2O$; 20 mg of Cu as $CuSO_4.5H_2O$; 1500 IU of Vitamin A; 400 IU of Vitamin D and 220 IU of Vitamin E

About 65% of *ad libitum* feeding (n = 6), this leve was objectived to keep the lambs for 150 g $day^{-1}$ weight inceas, it was almost 1/2 weight inceas between group 1 and 2: 65% of TMR complete diet and freedom drinkiing water. When the group of *ad libitum* intake reached 28 kg, randomly selected 6 lambs were fasting for 16 h and slaughtered. Then, the left lambs for *ad libitum* intake reached 35 kg, all the experimental lambs were slaughtered after which were fasting 16 h.

At slaughter, the lambs were killed by exsanguination using conventional human procedures. Blood were weighted and sampled, the body was weighted and separated into individual components then weighted separately. The components included internal organs (heart, liver, spleen, kidneys, lungs and trachea), genital system, head, feet, carcass, hide and wool, emptied and cleaned digestive tract (rumen, reticulum, omasum, abomasum and small and large intestines), the digestive tract was weighted before and after emptied and flusing with water. The carcass was split along the dorsal midline, researchers choose the right-half of carcass as well as the right-half head, hide, muscle, bone and the anterior and postrtior right feet then taken the 1/2 of total fat, internal organs, digestive tract and genital system. Each body sample was cut into samll speices, fully ground with a screw grinder, homogenized by 3 additional passes though the grinder then frozen at -20°C to preserve untill analyses.

**Digestibility trial:** The digestive trial was conducted simultaneously with the comparative slaughter trial. About 18 male lambs were breeded in metabolic cage, the digestive trial also feeded at 3 levels of feed intake (*ad libitum* feeding, 35% of *ad libitum* feeding and 65% of *ad libitum* feeding). The diet and feeding management were same as the described with the slaughter trial.

The digestibility trial was conducted for 16 days, it included 10 days adaptation period and 6 days for data and sample collection. The feeds, orts, feces and urine were weighed individually in the morning every day during the 6 days collection period. Reserved the 10% sub-sample collection of the fecal and feed offered and refused as the samples, all samples were oven-dried at 65°C for at least 72 h then pass through the 1 mm screen using a pulverizer and stored until analyses. After amounted the urine put it into buckets containing 100 mL of 7.2N $H_2SO_4$, for urinary N analysis. The volume was measured and a sample of 10 mL $L^{-1}$ of total volume was stored at -20°C until analyses. Samples of feeds, orts, feces and urine were pooled to an individual lamb total 6 days digestibility trial period.

### Chemical analyses

**Samples of feeds, orts, feces and urine:** Chemical analyses of feeds, orts and feces included Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Ether Extract (EE), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Gross Energy (GE), in the urine sample, besides the CP, GE, the allantoin and uric acid concentrations were also need to determine.

Ingredients were analyzed for the DM of sample by drying at 105°C for at least 8 h, the OM analysis was incineration at 600°C for 2 h, the CP was determined by Kjeldahl determination, the EE was assayed by loss in weight of the dry sample upon extraction with ethylether in a Soxhlet extraction apparatus for 10 h (AOAC, 1990), NDF was determined by the method according to Mertens (2002) the samples were weighed into polyester filter bags and treated with neutral detergent in an pulp mill digester at 110°C for 1 h, the ADF determined method like NDF, the difference is uesed as acid detergent. GE was determined by a bomb calorimeter. The allantoin and uric acid concentrations were determined by Colorimetric Method (Chen and Gomes, 1995).

**Body components:** All body components sample were freeze-dried except wool, chemical analyses included Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Ether Extract (EE) and Gross Energy (GE), the analysis method of them was assayed as earlier described.

### Data calculations and analyses

**Diet apparent digestibilities and microbial protein synthesis:** The diet apparent digestibilities was the proportion of animal nutrient intake without remaining in feces. Van Soest (1994) reported that only NDF of the feces is originated from the feed, Chen and Gomes (1995) used the urinary excretion of purine derivatives to estimate the microbial N (Nm) then reforming Nm to Microbial Crude Protein (MCP) (MCP = 6.25×N).

**Protein requirements for maintenance:** It was used to calculate protein requirement for maintenance. The intercept of this regression should be indicated the endogenous and metabolic losses of N because of the factor 6.25 which value was expressed to be the net protein requirement for maintenance.

**Statistical analyses:** The data from experiment were analyzed as a completely randomized design using SPSS 13.0. The linear regressions analyses were conducted with PROC REG. Residuals plotted against the predicted values were used to check the model assumptions for homoscedasticity, independency and normality of the errors. A data point was deemed to be an outlier and removed fromthe database if and only if the Studentized residual was outside the ±2.5 were considered to be outliers andwere removed fromthe dataset.

## RESULTS AND DISCUSSION

**Nutrient intake and growth performance:** As expected, the Average Daily Gain (ADG) was highly correlated with the DM intake (Table 2), DMI and ADG were significantly greater in the *ad libitum* treatment than those in the restricted feeding treatments ($p<0.05$) and the ratio of DMI to ADG was higher in the *ad libitum* treatment than those in fed 35% of *ad libitum* feeding ($p<0.01$). The 35% restricted feeding treatments was close to the borderline of maintenance requirements, therefore the ADG of this group was close to zero increase. In this experiment the average daily gain of *ad libitum* treatment was 287.6 g, it showed that in this experimental condition, the choice of feed TMR had good fattening effect.

**Diet digestibility and N balance (digestibility trial):** In the digestibility trial, values for apparent digestibility of OM, CP, NDF, ADF and EE were increase with the feed level which from high to low and had significant difference ($p<0.05$). The apparent digestibility of DM was not significant ($p>0.05$) between different treatments. N retention as well as rumen microbial protein synthesis was greater ($p<0.05$) for lambs at highest levels of intake, the urinary N was not significant ($p>0.05$) between different treatments, one outliers were removed from the dataset of urinary N. These values as well as those of true

Table 2: Results of animal feeding experiments

| Items | BL | IM | Alf | 65% Rf | 35% Rf |
|---|---|---|---|---|---|
| Number of lambs | 5 | 5 | 5 | 5 | 5 |
| BW (kg) | 21.69±0.35 | 29.26±0.24 | 36.39±0.21 | 29.87±0.41 | 21.50±0.08 |
| DMI (g $day^{-1}$) | - | 1524.33±56.09$^{a}$ | 1502±62.34$^{a}$ | 946.7±55.34$^{b}$ | 552.7±46.34$^{c}$ |
| ADG (g $day^{-1}$) | - | 298.00±8.75$^{a}$ | 287.6±21.23$^{a}$ | 150.4±45.34$^{b}$ | 8.3±2.12$^{c}$ |
| DMI/ADG | | 5.11±1.06$^{a}$ | 5.22±1.12$^{a}$ | 6.29±1.34$^{a}$ | 66.59±34.23$^{q}$ |

The different lowercase and capital letters in the same column show statistically differences at 0.05 levels, respectively the not adjacent who significant difference at 0.01 levels digestibility of OM and effciency of microbial protein synthesis were used to estimate MP intake of the lambs in the comparative slaughter trial (Table 3).

**Protein metabolism for different nutrient levels:** The CPI, FP and RP were increased with the elevated levels of restricted feeding had significant differences among treatments ($p<0.05$) and CPI of *ad libitum* treatment was significantly higher than the restricted feeding groups ($p<0.01$), urine protein differences between the three groups was not significant ($p>0.05$), the net protein utilization of 65% restricted feeding treatment was higher than the other two groups, the difference was not significant ($p>0.05$) (Table 4).

**Body composition of protein deposition:** As reduce of the nutritient level, the average protein intake and protein deposition of muscle were cut down and had significant difference ($p<0.05$). The protein deposition of bone and fat of the 35% restricted treatments were lower than *ad libitum* treatment and had significant difference ($p<0.05$) which of *ad libitum* treatment and 65% restricted treatments had no significant difference ($p>0.05$), the protein deposition of wool was more higher than other tissue and it in *ad libitum* treatment and 65% restricted treatments had no significant difference ($p>0.05$), the

Table 3: Apparent digestibility and N balance of all digestive tract for different nutrient levels

| | Level of feed intake | | |
|---|---|---|---|
| Items | AL | 65 | 35 |
| Number of lambs | 5 | 5 | 5 |
| **Apparent digestibility** | | | |
| DM | 69.65±1.33$^{a}$ | 76.23±1.14$^{ab}$ | 77.98±1.40$^{ab}$ |
| OM | 66.34±1.12$^{a}$ | 75.56±1.23$^{ab}$ | 79.34±1.22$^{b}$ |
| CP | 58.68±1.34$^{a}$ | 65.45±2.24$^{ab}$ | 71.78±1.89$^{b}$ |
| NDF | 48.55±1.09$^{a}$ | 54.34±1.11$^{a}$ | 67.45±1.76$^{b}$ |
| ADF | 44.56±2.22$^{a}$ | 50.23±1.43$^{a}$ | 57.34±1.23$^{b}$ |
| EE | 62.28±3.82$^{b}$ | 67.1±4.11$^{ab}$ | 69.58±3.74$^{a}$ |
| **N balance** | | | |
| Intake | 171.02±14.1$^{a}$ | 102.61±0.12$^{b}$ | 59.86±0.88$^{c}$ |
| Fecal | 59.46±13.34$^{a}$ | 32.62±3.25$^{b}$ | 20.69±3.12$^{c}$ |
| Urinary | 31.63±7.96$^{a}$ | 26.36±8.9$^{a}$ | 23.70±11.82$^{a}$ |
| Digestible | 111.56±19.19$^{a}$ | 69.70±3.25$^{b}$ | 39.17±3.12$^{c}$ |
| Retention | 79.93±21.01$^{a}$ | 43.63±9.69$^{b}$ | 15.47±9.75$^{c}$ |

The different lowercase and capital letters in the same column show statistically differences at 0.05 levels, respectively

Table 4: Results of crude protein in experiments

| Items | Alf | 65% RF | 35% RF |
|---|---|---|---|
| CP Intake (CPI) (g day$^{-1}$) | 223.38±5.89$^{a}$ | 132.55±4.55$^{b}$ | 78.21±2.48$^{c}$ |
| Fecal Protein (FP) (g day$^{-1}$) | 93.31±4.83$^{a}$ | 48.34±3.99$^{b}$ | 25.13±1.53$^{c}$ |
| Urine Protein (UP) (g day$^{-1}$) | 68.88±2.87$^{a}$ | 61.43±1.28$^{a}$ | 53.55±2.24$^{a}$ |
| Retention of Protein (RP) (g day$^{-1}$) | 66.88±1.34$^{a}$ | 27.31±1.20$^{b}$ | -1.23±0.34$^{c}$ |
| Net Protein Utilization (NPU) (%) | 28.32±1.13$^{a}$ | 31.28±1.11$^{ab}$ | 18.84±2.11$^{b}$ |

The different lowercase and capital letters in the same column show statistically differences at 0.05 levels, respectively the not adjacent who significant difference at 0.01 levels

protein deposition of blood and visceral had no significant difference between each groups ($p>0.05$) (Table 5).

**Protein requirements for growth:** Correlation analysis between DMI, CPI, $W^{0.75}$ and $\Delta W$, there has a certain relevance among them then made a regression analysis, obtained the regression equation for:

$$DMI\,(g\,day^{-1}) = 56.743\,W^{0.75} + 3.425\Delta W - 69.632$$
$$(r^2 = 0.935,\ n = 25,\ p<0.05)$$
$$CPI\,(g\,day^{-1}) = 7.163\,W^{0.75} + 0.496\Delta W - 9.438$$
$$(r^2 = 0.949,\ n = 25,\ p<0.05)$$

Where:

DMI = Dry Matter Intake
CPI = Crude Protein Intake (g day$^{-1}$)
$W^{0.75}$ = Metabolic body weight (kg)
W = Average daily gain (g day$^{-1}$)

**Different nutrient levels on the impact of sheep on growth performance:** Nutrient levels had a greater influence on the production performance of the lambs, Cannas and Atzori (2005) pointed out that improve the level of feeding, usually increase the chyme of the rate and rumen bypass of nutrients, reduce the energy loss caused by the fermentation, decline in the proportion of rumen acetate, propionic acid has risen. This is equivalent to increase the energy value of the rumen fermentation products, to improve the production performance of ruminants. In this experiment, the feed conversion efficiency of *ad libitum* was about 5.76, it was higher than in the past reported may be involved in this test in experimental animals month old. Lambs in the young stage because of fast growth, the protein and water of weight gain were higher and fat content was lower, the energy of unit weight was low thus the feed conversion efficiency was high. Increase feed efficiency of the restricted feeding group may be due to it used to maintain the level of the proportion of the total feed intake increased and feed efficiency showed an increasing trend.

Table 5: Body composition at different nutritient levels of protein deposition

| | Nutritient levels | | |
|---|---|---|---|
| Items | Alf | 65% RF | 35% RF |
| CP intake (g/kgW$^{0.75}$/day) | 13.37±0.880$^{a}$ | 10.91±0.110$^{b}$ | 5.31±0.070$^{c}$ |
| **Protein deposition (g/kgW$^{0.75}$/day)** | | | |
| Bone | 0.24±0.070$^{a}$ | 0.21±0.010$^{ab}$ | 0.06±0.000$^{b}$ |
| Blood and visceral | 0.13±0.020$^{a}$ | 0.07±0.140$^{a}$ | -0.05±0.010$^{a}$ |
| Fat | 0.09±0.010$^{a}$ | 0.06±0.010$^{ab}$ | 0.02±0.000$^{b}$ |
| Muscle | 0.98±0.002$^{a}$ | 0.53±0.001$^{b}$ | -0.04±0.003$^{c}$ |
| Fur | 0.41±0.020$^{a}$ | 0.25±0.130$^{ab}$ | 0.04±0.010$^{b}$ |
| Wool | 2.66±0.670$^{a}$ | 2.96±0.600$^{a}$ | 1.90±0.550$^{b}$ |

The different lowercase and capital letters in the same column show statistically differences at 0.05 levels, respectively and the not adjacent who significant difference at 0.01 levels

**Different nutrient levels on the impact of sheep on apparent digestibility:** The digestibility of all nutrition indicators showed that it had increasing trend with the treatment of restricted feeding level increased gradually. The increase of animal feed, dietary intake will usually accelerate the speed of the chyme through the intestine, it made shorten the duration of the feed and microbial or digestive enzymes thus reduce digestibility. Colmenero and Broderick (2006) study found that used the 2.0-2.5 times of the maintain level for ruminants to feed could achieve the purpose of growth and fattening but for every double of requirement for maintain level, the feed digestibility of ruminant reduce 0.02-0.03, the trend of digestibility in this experiment was similar to this theory. Fernandes *et al*. (2007) selected 21 hybrid boer goats, the lambs were randomly divided into 3 treatments: *ad libitum* feeding group, 40% of *ad libitum* feeding group and 70% of *ad libitum* feeding group, the result of feeding trial showed that dry matter digestibility with limited feeding elevated levels of the corresponding increase in. But the group did not show statistically significant difference, the experimental results in the study obtained with the similar, the dry matter digestibility significant difference between the *ad libitum* feeding group and 35% restricted feeding group, analysis of this phenomenon may be due to different experimental animal species and differences in the feed nutrient levels. The crude protein digestibility of *ad libitum* feeding treatment was closer to 70% restricted feeding treatment, no significant difference; the crude protein digestibility of 40% restricted feeding treatment was significantly higher than the other two groups. Clark *et al*. (2007) study pointed out that the crude protein digestibility had a little change between *ad libitum* feeding treatment, 80 and 60% restricted feeding treatment. The results of this study is consistent with their findings.

**Different nutrient levels on the impact of sheep on N balance:** The Maintenance Requirement for Net Protein (MRNP) is assumed to be the sum of endogenous urinary N, metabolic fecal N and dermal N losses, multiplied by the factor 6.25. When N retention in the gain is regressed against a measure of N supply, the negative intercept at zero N intake provides an estimate of minimum N losses which should be similar to the sum of endogenous urinary N and metabolic fecal N (AFRC, 1998).

The urinary protein loss is a decreasing trend with the increase of restricted feeding level. But did not reach statistical significant. Utilization of crude protein was became higher with the increase of restricted feeding level, that of 65% restricted feeding treatment was maximum, 35% restricted feeding treatment was minimum.

The increase in crude protein intake chyme speed to accelerate through the entire digestive tract, it was reduced the contact time of crude protein with microorganisms and enzymes in the digestive tract, caused the protein digestibility decreased. Therefore, the increase in feed intake makes the level of protein loss in the feces increased significantly, net protein utilization also showed a downward trend. In addition, the test for each treatment group in this experiment sheep urine although the loss of crude protein increased with the feed intake, loss of larger trends in each group were no significant differences may be generated due to the crude protein in the urine is mainly the oxidative decomposition of the substances in the body while similar to the amount of protein consumed by individual animals *in vivo* metabolism. Study showed that of the N balance between *ad libitum* feeding treatment, 70 and 40% restricted feeding treatment also supported this conclusion.

**Body composition of protein deposition on different nutrient levels:** In *Ovis aries*, it taken 6.6 g day$^{-1}$ of the average yield of wool as the basic, the protein of wool content was 800 g kg$^{-1}$ and the average protein deposition of wool was 5.3 g day$^{-1}$ (AFRC, 1993). Lots of researches have indicated that the body fat content of growth sheep was increases with increasing nutrition level and body protein content was relatively stable, it was had little influence by nutrition level, the results of the study was basically identical with above resluts. Ash and Norton (1987) reported that in Australia Cashmere goat, the relative ratio for body each organ was no significant effect in different nutrition level ($p>0.05$), the separable fat in the *ad libitum* treatment than those in the restricted treatments ($p<0.05$).

## CONCLUSION

Muscle, bones, blood, fur and wool as the major deposition of body protein body composition, the protein deposition in the same diet at different feeding levels, along with raising the level of decline was a downward trend. With the reduction of the nutrient levels, the protein digestibility was increase and protein deposition rate was decline as the protein intake is decreasing, used to deposit the protein progressively decreasing. Trends in deposition of protein accounted for the proportion of the protein intake was as same as protein deposition, it indicated that the high energy intake was beneficial to improve the protein deposition and net protein utilization. According to the principles of animal nutrition, maintain body weight constant for animal of growth period, the body's metabolism of nutrients was keeping a dynamic changes, catabolic capacity and anabolic capacity of animals remain unchanged under different conditions but can not maintain body composition ratio between the constant. In addition to the wool oil, hair in essentially 100% of the protein. A large number of studies have shown that the growth of the sheep body fat content increased with increased nutrient levels but the protein content was relatively stable, it was less affected by the nutritional level, in this study, these findings are basically as the same.

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