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# Effects of Energy and Protein Levels of Maternal Diets at Late Gestation on Growth, Health and Performance of Goat Kids

**Research Article**

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## ABSTRACT

A study was conducted to evaluate the effects of energy and protein levels of maternal diets on growth, some blood parameters, health, and performance of baby goat kids at first month of life. On 95 d after successful mating, 28 synchronized singleton pregnant Sistani goats were randomly allocated to four treatments including 1) low protein and low energy (LPLE), 2) high protein and low energy (HPLE), 3) low protein and high energy (LPHE), and 4) high protein and high energy (HPHE) diets. In all treatments, body weight (BW) reduced at 1d and 28 d after party. The birth BW of kids was similar between the four groups but LPLE, LPHE and HPHE had numerically lower birth weight. The kids from nanny goats fed on high protein diets had greater BW and average daily gain (ADG) than those of others on days 7, 14, 21, 28. Plasma triglyceride and total protein were significantly high in HPHE and glucose concentrations were increased in HPLE. Milk production increased in response to prepartum crude protein (CP). The results show that maternal nutrition had a positive effect on weight and biometric traits of kids.

**KEY WORDS** energy and protein levels, gestation, goat kids, performance.

## INTRODUCTION

Maternal nutrition during the different stages of pregnancy can induce permanent changes and postnatal effects on the structure, growth, skeletal muscle development, body composition, productivity, reproductive physiology, and metabolism in offspring (Long *et al.* 2010; Radunz *et al.* 2012). Underfeeding pregnant sheep can have deleterious effects on fetal and / or newborn lambs by adversely affecting placental size, fetal growth, deposition of fetal fat reserves for use after birth, maternal udder development and colostrum/milk production (Gao *et al.* 2008). During the late gestation, the last two months of pregnancy, eighty percent of the fetal growth occurs, leading to a significant increase in nutrient requirements of the ewe (Bell, 1995). Therefore, nutrition in the final stages of pregnancy in sheep and goats is one of the very important factors, and depends upon many qualities after birth. However, information on the effects of intake of dietary protein and energy during late gestation and postpartuemof gaot kids is limited. The prepartum diets during mid to late gestation in sheep had significant effects on postnatal carcass composition in terms of both fat and muscle deposition (Radunz *et al.* 2010). Dietary components, such as protein content or fat supplementation, have been associated with alterations in the offspring performance. Maternal protein supplementation during late gestation has been positively associated with postnatal growth and adipose deposition in steers (male progeny), and also post weaning BW and fertility in heifers (female progeny) in beef cattle (Larson *et al.* 2009). Maternal energy sources, such as starch or fiber, may also impact fetal development and subsequent performance of the offspring. Maternal starch based diets in cattle has been associated with greater calf birth weights compared with fiber-based prepartum diets (Radunz *et al.* 2011). Hatfield *et al.* (1995) reported that the birth weight of lambs was greater when the ewes were fed 14.9% CP compared to the one that fed 11.3% CP during late gestation and early lactation. Improvement of in uterus nutrition expanded the number of fibers that form muscle cells and generated growth of muscle fiber cells reached a maximum during the period of postnatal growth (Murniati *et al.* 2013). Under-nutrition during the first half of gestation may not impact birth weights, but has been demonstrated to impact metabolic function of sheep and cattle offspring that results in altered production and body composition later in life (Long *et al.* 2010). Under-nutrition during the last third of pregnancy will decrease birth weights with a potential negative impact on long-term growth and body composition of the progeny. Over-nutrition can also restrict placental and fetal development, resulting in decreased birth weights, post-natal growth, and altered body composition (Vonnahme and Lemley, 2012). Fernandez *et al.* (1989) did not observe changes in birth weight of kids in response to prepartum energy or protein. In sheep, Gardner *et al.* (2005) observed that a 50% restriction on energy for 110 d of gestation to parturition did not impact birth weights, but reduced glucose tolerance and caused insulin resistance in lamb progeny. Vonnahme and Lemley (2012) reported that providing protein supplementation to cows beginning on day 190 of gestation resulted in a doubling of uterine blood flow when compared with non-supplemented cows. Cottrill *et al.* (2008) concluded that recommendations for sheep feeding systems should be revised because when the recommendations were compared there was variation of maintenance energy requirement from 0.33-0.41 MJ/kg$^{0.75}$. This triggers a need for the energy requirements for sheep and goat to be reviewed, as a failure to do so could result in sheep or goat having lower growth rates and poor productivity, which furthermore has implications for welfare and production costs.

Therefore, the objective of this study was to assess the effect of energy and protein levels of maternal diets at late gestation on growth, some blood parameters, health, and performance of baby goat kids in first month of life as well as biometrical characteristics.

## MATERIALS AND METHODS

The experiment was conducted in the Sari Agricultural Sciences and Natural Resources University of Iran. Humane animal care and handling procedures were followed according to the University's animal care committee.

At 100 d after successful mating, 28 synchronized singleton pregnant Sistani goats (3 years old; 25±1.6 kg BW, body condition score=2.6±0.5) were randomly allocated to four treatments including 1) low protein and low energy (LPLE), 2) high protein and low energy (HPLE), 3) low protein and high energy (LPHE), and 4) high protein and high energy (HPHE) diets. One week prior to the experiment, goats were dewormed and placed in individual stalls with feeding troughs to supply the diets and water, and gradually adopted to the experimental diets. The experimental diets were formulated according to the NRC (2007) for pregnant goat and 10% greater than the recommended energy and protein requirement as low and high level, respectively. The ingredients and chemical compositions of the experimental diets are shown in Table 1. The diets were provided twice per day, at 7 am and 7 p.m. feed total mixed ration (TMR) *ad libitum*, being adjusted daily to allow approximately 10% leftovers based on the previous day's intake. Feeds and rations samples were dried at 55 ˚C, ground through a Wiley mill (1 mm screen), and composted by the animal. Samples were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE) (AOAC, 2002), acid detergent fiber (ADF), neutral detergent fiber (NDF) (Van Soest *et al.* 1991; using heat resistant alpha amylase without sodium sulfate), and ash. Non fibrous carbohydrates (NFC) was calculated from 100 - [CP (%) + NDF (%) + Ash (%) + EE (%)] (Table 1).

The goats were weighed at the start of the experiment, before and after parturition, and 28 d after parturition. Milk production was measured with weighing kids before and after suckling at 7 a.m., 12 a.m., 6 p.m. and 10 p.m. hours. The blood samples were taken at 28 d from the jugular vein, centrifuged immediately at 1500 × *g* for 20 min, and their plasma was poured into a plastic tube and stored at -20 ˚C until assayed for glucose, triglyceride, total cholesterol, total proteins, and urea concentrations. These blood parameters were evaluated using colorimetric kits (Pars Azmoon®, Tehran, Iran). Also, kids were weighted immediately after birth and weekly for 28 d after parturition before suckling. The BW was measured by a digital scale with a 50 g sensitivity along with seven biometric traits of each animal following standard procedure and anatomical reference points as indicated in Figure 1 (Yakubu, 2010). All data were analyzed using the factorial 2 × 2 experiment in a complete randomize deign by the PROC GLM of SAS (2002). The following model was used:

$$Y_{ijk}= \mu + A_i + B_j + AB_{ij} + \varepsilon_{ijk}$$

Where:

$Y_{ijk}$: represents the tested variable.

$\mu$: overall mean.

$A_i$: effect of the protein.
$B_j$: effect of the energy.
$AB_{ij}$: interaction of energy and protein.
$\varepsilon_{ijk}$: residual error.

## RESULTS AND DISCUSSION

### Body weight, intake, and milk production

The effects of protein and energy levels on BW, dry matter intake (DMI) and milk yield of goats are presented in Table 2. The BW of goats at 1 d after parturition and 28 d of lactation were not affected by protein and energy contents of rations. Sahlu *et al.* (1995) reported that the additional BW during gestation were probably due to increased amniotic fluid or placental mass and were lost at parturition, resulting in the similar BW at the beginning of lactation. Also lower prenatal BW losses for ewes fed lower protein diet could be attributed to lower milk production because of protein limitation. In contrast to our result, Cottrill *et al.* (2008) found increased protein supplementing and herbage allowance to induce BW gain. The effects of dietary protein and energy levels during late gestation on the subsequent lactation of dairy goats are not consistent. Sahlu *et al.* (1995) reported that milk production increased quadratically with prepartum protein concentration and was greater for the high concentration of prepartum energy. Fernandez *et al.* (1989) reported an increase in milk production of Alpine goats at high prepartum dietary energy intake. In this experiment, prepartum DMI increased when prepartum protein intake increased. In addition, DMI during the postpartum was affected by protein and energy levels. In Sahlu *et al.* (1995) study, as gestation progressed, DMI increased by increase in dietary protein concentration which was relateo to changes in the fractional passage rate of digesta from the rumen. The DMI also may be affected by the dietary protein if it enhances the ruminal retention time (Bandyk *et al.* 2001).

### Body weight and average daily gain of kids

The frequency of male and female kids and the birth BW of kids was similar between the four groups (Table 3). There are a number of factors that affect fetal growth and thus eventual kids birth weight, including maternal feeding program, litter size, dam parity, sex of the offspring, maternal characteristics, and transgenerational effects (Long *et al.* 2010; Radunz *et al.* 2012). The birth weight is a significant important characteristic because it is highly correlated with the rate of growth, adult size, growth patterns of lambs, and has positive genetic correlation with further live weights (Radunz *et al.* 2012). Also, lamb survival, especially the first hours postpartum, is affected by birth weight. The main reasons for that is probably more effective thermoregulation and energy supply and greater resistance to infections with increasing birth weight. The latter effects can also be caused by a greater amount of colostrum available to and consumed by the heavier lambs, probably also borne to better nourished dams. There were no significant differences in birth weights of kids between the four nutritional treatments. It is well known that dams' nutrition in late pregnancy can affect birth weight of lambs. Annett *et al.* (2008) found positive effect of undegradable protein on birth weight.

However, Choi *et al.* (2005) reported no significant differences in feed intake and feed efficiency when Korean black goats were fed diets with different protein levels. Also, Sharifi *et al.* (2014) found that different levels of protein had no significant effects on performance parameters of Iranian Sannen kids such as DMI, average daily gain (ADG) and feed efficiency, but as the amount of protein in the diet increased, DMI, ADG and feed efficiency tended to increase. By the way, when ewes were fed with a diet designed to provide either 100 or 160% of their energy requirements, no differences in lamb birth weight were noted (Muhlhausler *et al.* 2006).

Bandeira *et al.* (2016) supplied iso-nitrogenous diets that had the same energy values and found BW increased linearly with increases in the energy concentration in the diet. Energy is a dietary element that is responsible for differential utilization of nutrients during development and thereby affects the productivity and gain of an animal (NRC, 2007). Gardner *et al.* (2005) found that energy intake in the late gestation had a significant influence on weight at birth. In addition, maternal body condition score prior to conception had a significant effect on birth outcome. However, in this experiment, diet with 10% energy concentration greater than NRC (2007) showed no significant effect on birth weight of lambs but protein concentration inceased birth weight of lambs.

Overall BW and ADG of kids at 7, 14, 21, 28 d were greater in high protein diets than the others ($P<0.05$; Table 1). Despite the significant effects of energy concentrations at 15-21 d and in whole period of the experiment, the interaction effects of protein and energy on the BW and ADG of kids were not significant. Protein is an essential nutrient for animal growth and plays an important role in muscle growth and animal development. Negesse *et al.* (2001) reported an increase in BW gain for Sannen kids fed 17.6% CP diet compared to diets with 14.4%, 11.4% and 8.7% CP levels. But, BW gain and feed conversion efficiency in Barbari kids was similar when fed with different protein levels in the diet (Dutta *et al.* 2009). Also, Hwangbo *et al.* (2009) found that low feed efficiency for Korean black goats fed with 18% CP level compared to 20, 16 and 14% CP levels.

**Table 1** Ration ingredients and compositionsfed to dairy goats in late gestation and early lactation

| **Factor** | **Treatments** | | | |
|---|---|---|---|---|
| Energy | Low | | High | |
| Protein | Low | High | Low | High |
| **Ingredients (%) of ration in late gestation** | | | | |
| Barley grain | 16.59 | 14.00 | 8.83 | 18.11 |
| Corn dry | 23.32 | 12.30 | 40.35 | 9.53 |
| Beet pulp | 7.26 | 13.10 | 1.16 | 23.83 |
| Wheat bran | 2.07 | 8.70 | 3.59 | 0.00 |
| Soybean meal | 2.07 | 3.00 | 0.00 | 1.91 |
| Alfalfa hay | 20.84 | 21.00 | 7.37 | 20.02 |
| Wheat straw | 26.95 | 27.00 | 37.83 | 25.74 |
| Dicalcium phosphate | 0.90 | 0.90 | 0.87 | 0.86 |
| **Chemical composition** | | | | |
| Metabolizable energy (Mcal/day) | 2.146 | 2.146 | 2.355 | 2.354 |
| Dry matter (%) | 77 | 83 | 78 | 84 |
| Crude protein (%) | 9.90 | 10.61 | 9.01 | 9.80 |
| Neutral detergent fiber (%) | 42.43 | 47.22 | 40.37 | 41.28 |
| Ash (%) | 6.09 | 6.70 | 5.62 | 5.90 |
| Ether extract (%) | 2.41 | 2.22 | 3.03 | 2.35 |
| Non fiber carbohydrate (%) | 39.17 | 33.25 | 41.97 | 40.67 |
| **Ingredients (%) of ration in early lactation** | | | | |
| Barley grain | 8.41 | 13.35 | 9.68 | 7.12 |
| Corn dry | 20.75 | 15.16 | 31.34 | 29.63 |
| Soybean meal | 0.000 | 2.86 | 0.000 | 2.67 |
| Wheat bran | 12.90 | 12.39 | 0.000 | 4.45 |
| Beet pulp | 14.95 | 12.39 | 15.85 | 14.32 |
| Alfalfa hay | 6.54 | 12.39 | 8.80 | 8.90 |
| Wheat straw | 34.58 | 29.25 | 32.57 | 31.14 |
| Dicalcium phosphate | 1.87 | 1.91 | 1.76 | 1.78 |
| **Chemical composition** | | | | |
| Metabolizable energy (Mcal/day) | 2.255 | 2.256 | 2.475 | 2.476 |
| Dry matter (%) | 89 | 89 | 89 | 89 |
| Crude protein (%) | 8.81 | 10.36 | 8.10 | 9.34 |
| Neutral detergent fiber (%) | 47.52 | 46.19 | 42.18 | 42.47 |
| Ash (%) | 7.27 | 7.45 | 6.55 | 6.79 |
| Ether extract (%) | 2.53 | 2.40 | 2.45 | 2.52 |
| Non fiber carbohydrate (%) | 33.87 | 33.6 | 40.72 | 38.88 |

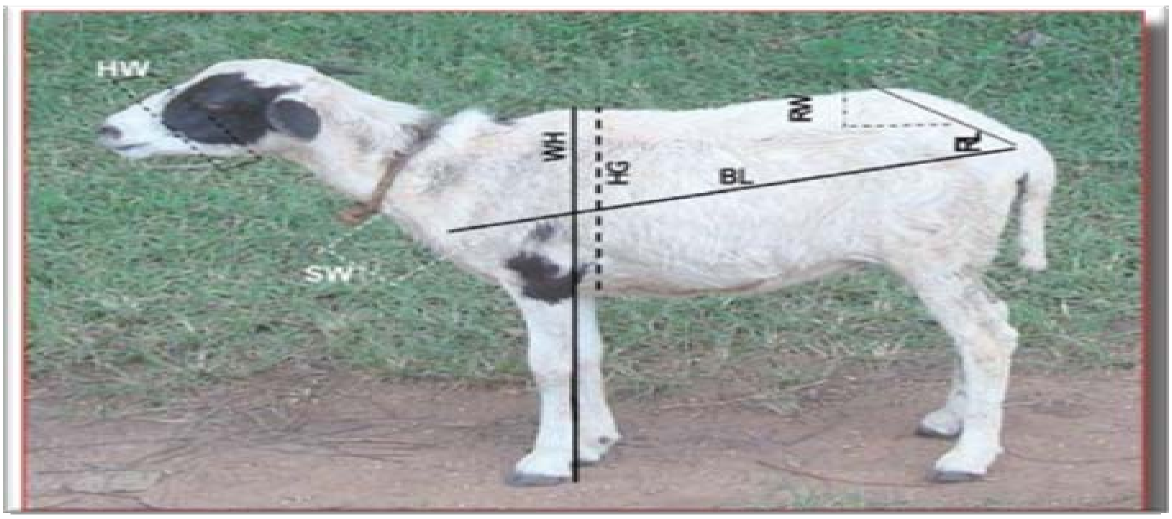


**Figure 1** The anatomical parts measured in this study
The body parts consisted of withers height (WH), distance between the most cranial palpable spinous process and the ground, body length (BL), measured from distance between the tip of scapula to tail drop, heart girth (HG), width between the hip bones (tuber coxae), rump length (RL), measured from hips (tuber coxae) to pins (tuber ischii), shoulder width (SW), measured as a distance from left to right upper arm, and head width (HW) measured as the widest point of the head and rump width (RW), width between the hip bones (tuber coxae) (Yakubu, 2010)

Table 2 Effects of maternal feeding of goats with low and high energy and protein diets on weight, feed intake milk and colostrum production

| | Treatments | | | | SEM | P-value | | |
|---|---|---|---|---|---|---|---|---|
| **Energy** | Low | | High | | | Protein | Energy | Protein × energy |
| **Protein** | Low | High | Low | High | | | | |
| **Weight (kg)** | | | | | | | | |
| 28 d before kidding | 25.486[ab] | 28.486[a] | 24.033[b] | 27.014[ab] | 0.574 | * | NS | NS |
| 1 d after kidding | 23.486 | 25.714 | 22.967 | 23.986 | 0.651 | NS | NS | NS |
| 28 d after kidding | 22.300 | 22.771 | 20.600 | 22.557 | 0.738 | NS | NS | NS |
| **Before kidding** | | | | | | | | |
| DMI (g $day^{-1}$) | 893.23[b] | 1282.22[a] | 996.40[b] | 967.55[b] | 27.56 | ** | * | ** |
| **After kidding** | | | | | | | | |
| DMI (g $day^{-1}$) | 913.89[c] | 1028.87[b] | 1034.17[b] | 1152.20[a] | 16.61 | ** | ** | NS |
| Milk yield (g/month) | 17715 | 21473 | 17585 | 18984 | 659.699 | NS | NS | NS |
| Colostrum (g/week) | 4733.1 | 4817.6 | 4275.0 | 3834.3 | 221.7 | NS | NS | NS |

DMI: dry matter intake.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.
NS: non significant.
* (P<0.05) and ** (P<0.01).

Table 3 Effects of maternal feeding of goats with low and high energy and protein diets on weight and average daily gain of kids

| | Treatments | | | | SEM | P-value | | |
|---|---|---|---|---|---|---|---|---|
| **Energy** | Low | | High | | | Protein | Energy | Protein × energy |
| **Protein** | Low | High | Low | High | | | | |
| **Body weight (g)** | | | | | | | | |
| At birth | 2877.1 | 3084.3 | 2885.6 | 2980.0 | 61.570 | NS | NS | NS |
| 7 d | 3466.7[b] | 3910.0[a] | 3355.0[b] | 3757.5[ab] | 65.379 | ** | NS | NS |
| 14 d | 4173.3[ab] | 4831.4[a] | 3952.1[b] | 8.4530[ab] | 113.210 | * | NS | NS |
| 21 d | 4745.0[b] | 5795.7[a] | 4492.1[b] | 8.5125[ab] | 142.854 | ** | NS | NS |
| 28 d | 5380.0[b] | 6634.3[a] | 5107.9[b] | 5741.7[ab] | 165.852 | * | NS | NS |
| **Average daily gain (g/d)** | | | | | | | | |
| Days 0-7 | 87.50[ab] | 117.96[a] | 67.06[b] | 105.00[ab] | 6.202 | * | NS | NS |
| Days 8-14 | 100.95[a] | 113.63[a] | 85.31[a] | 110.48[a] | 9.040 | * | NS | NS |
| Days 15-21 | 81.67[b] | 137.76[a] | 77.14[b] | 85.00[b] | 7.179 | * | * | NS |
| Days 22-28 | 90.71[b] | 119.80[a] | 87.96[b] | 87.98[b] | 6.714 | ** | NS | NS |
| Overall | 90.21[b] | 126.79[a] | 79.37[b] | 97.11[b] | 5.003 | * | * | NS |

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.
NS: non significant.
* (P<0.05) and ** (P<0.01).

Negesse *et al.* (2001) found increase of the ADG in Saanen kids with the diet containing 17.6 compared to 14.4, 11.4 and 8.7% CP level. Fernandez *et al.* (1997) observed no significant difference in the ADG of goats fed with diets containing 9.5 and 14% of protein. Hwangbo *et al.* (2009) fed the Korean black goats with 20, 18, 16, and 14% CP and in agreement with our study they found that increase of CP level significantly increased ADG in Saanen kids. In addition, Shahjalal *et al.* (2000) fed black Bengal goats with diets containg 16.9 and 20.35% CP and found a greater ADG with increasing dietary protein. However, Nuno *et al.* (2009) reported that the protein levels in the diet (14, 16 and 18%) had little or no effect on the performance of Dorper or Pelibuey lambs during fattening which is in disagreement with our results. In particular, protein is an essential nutrient for animal growth and development, and thus a sufficient protein supply is a crucial factor for normal growth.

The prepartum diets can affect the performance of the offspring, including postnatal growth and ADG. Skeletal muscle mass is largely determined by the number and the size of muscle fibers. Muscle fibers are formed exclusively during the prenatal stage, especially from early to mid-gestation, and there is no further net increase in the number of these fibers after birth (Radunz *et al.* 2011). In contrast, the size of muscle fibers depends proliferate, synthesize myofibrilllar proteins, and fuse with existing muscle fibers to increase muscle fiber size which starts to occur in late gestation and continues in postnatal development (Radunz *et al.* 2011). Therefore, programming of muscle tissue during fetal development which could lead to a lesser number and smaller size of muscle fibers would reduce muscle mass and have negative effects on efficiency of animal production. However, the maternal nutrition can alter the composition and abundance of fetal skeletal muscle and fat depots that may affect livestock production.

In this experiment, 10% of CP concentration greater than NRC (2007) recommendation, increased the BW and ADG of kids at 7, 14, 21, 28 d, and in whole period of the experiment. However, energy concentration had no effect on the BW and ADG of kids. The present study has characterized the effects of maternal feed protein during mid-to-late gestation on the ADG of goats' kids. These prepartum maternal diets may be caused notable gene expression changes in fetal adipose and muscle tissues. Therefore, uture studies are needed for determination of the potential effects of these maternal diets on epigenetic modifications in the fetal genome.

**Blood parameters in kids**

The effect of dietary treatments on some blood parameters is shown in Table 4. Concentration of plasma glucose was greater in kids fed HPLE diet without difference among LPLE and HPHE treatments. The glucose concentration in LPHE was significantly lower than HPLE treatment but was significantly greater than LPLE and HPHE rations. The interaction of protein and energy had a significant effect on glucose concentration ($P<0.0043$). The reference values of the blood ovine including total glucose (mg/dL), cholesterol (mg/dL), globulin (g/dL), total proteins (g/dL), albumin (g/dL), and urea (mg/dL) were 50.0 to 80.0, 52.0 to 76.0, 3.5 to 5.7, 6.0 to 7.9, 2.4 to 3.0, and 51.5 to 128.5, respectively (Kaneko *et al*. 2008). However, in all treatments blood glucose concentrations were above those normal, suggesting excessive intake of DM and protein or having a non-developed reticulorumen tract. However, in newborn, weaned, and pre-ruminating kids blood glucose concentrations may be greater than the concentration of mature goat.

Concentration of plasma triglycerid were greater in kids fed LPHE diet. While in LPLE and HPLE treatments were similar but HPHE treatments had the least triglycerid concentration. The interaction of protein and energy had a significant effect on triglycerid concentration ($P<0.0077$). He *et al.* (2015) investigated the effects of maternal protein or energy restriction on hormonal and metabolic status of pregnant goats during late gestation and their postnatal male kids. After 6 weeks of nutritional recovery, plasma concentrations of most metabolic and hormonal parameters in restricted kids were similar to control kids, except for reduced insulin concentration. As the plasma concentration of nonesterified fatty acids (NEFA) is correlated to energy balance, its concentration increased in restricted kids corresponding to a high rate of lipolysis in adipose tissue, the increased plasma NEFA concentration suggested that the restricted goats mobilized body fat reserves in a catabolic state. Considering a higher NEFA concentration would help restrain the use of glucose to synthesize glycogen and fat, the elevated plasma NEFA, similar to lower insulin concentration or higher triglycerid concentration. Plasma triglyceride concentration increased for high energy diet (HELP). A gradual increase of triglyceride concentration happened during the first week of life of calves. The high concentrations of triglyceride on the first day of life may be related to colostrum and milk intake because of their high chylomicrons and very low density lipoproteins (VLDL) content (Abdolvahabi *et al.* 2016).

The cholesterol and total protein concentration was different among treatments. The HPHE and LPHE treatments had the most and least concentration of cholesterol (Table 4). Also, the HPHE and LPHE treatments had the most and least concentration of total protein. However, there was no difference in blood urea concentration among treatments. Plasma cholesterol concentration increased for high energy diet (HEHP). The increasing pattern in cholesterol concentration also may be attributed to high intake of dietary fat provided by colostrum and milk. Plasmatic proteins are synthesized mainly in the liver and skeletal muscle and are abundant in blood plasma (Kaneko *et al*. 2008). Plasma protein concentration increased for high protein-high grain diet. This finding was in agreement with those reported by El-Shabrawy (2006) and Abdel-Ghani *et al.* (2011). They reported a positive correlation between dietary protein and serum total protein concentration in goats. In addition, concentration of plasma glucose were higher in kids fed higher concentration of dietary protein (HPLE). Feeding protein with high rumen undegradable value resulted in increased concentration of blood glucose due to more glucogenic amino acids available for gluconeogenesis. Increase in glucose concentration may be due to more bypass protein and increased availability of glucogenic amino acids for glucose synthesis. In contrast, Rusche *et al.* (1993) observed that feeding CP source with high escape protein decreased plasma glucose and urea N concentration. The higher concentration of glucose in young ruminants may be related to different metabolism. In kids, blood glucose comes from lactose after digestion of milk while in adults; it comes mainly from liver gluconeogenesis because of rumen carbohydrates metabolism.

**Biometric traits**

The effects of maternal feeding of goats on biometric traits in kids at 10, 20, and 28 d after birth are presented in Table 5. Also, the correlation between BW at birth, 14, and 28 d, milk intake, and some biometric traits of kids are presented in Table 6. Body weight of kids were significantly different between treatments and the LEHP treatment had significantly greater BW at birth, and 14, and 28 d of age. Body weight is an important economic trait in the selection of animals. The main purpose of animal breeding practices is to improve traits of economic value.

Table 4 Effects of maternal feeding of goats with low and high energy and protein diets on some blood metabolits of kids

| | Treatments | | | | SEM | P-value | | |
|---|---|---|---|---|---|---|---|---|
| Energy | Low | | High | | | | | |
| Protein | Low | High | Low | High | | Protein | Energy | Protein × energy |
| Glucose (mg/dL) | 76.19[c] | 109.05[a] | 97.35[b] | 81.02[c] | 3.678 | NS | NS | ** |
| Triglycerid (mg/dL) | 61.00[b] | 60.50[b] | 73.17[a] | 42.33[c] | 4.442 | NS | NS | ** |
| Cholesterol (mg/dL) | 143.17[b] | 129.20[c] | 110.00[d] | 152.00[a] | 1.645 | NS | NS | ** |
| Total protein (mg/dL) | 7.72[ab] | 7.741[ab] | 7.04[b] | 8.85[a] | 0.219 | * | NS | * |
| Urea (mg/dL) | 9.83 | 10.33 | 8.66 | 9.50 | 0.395 | NS | NS | NS |

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.
NS: non significant.
* (P<0.05) and ** (P<0.01).

Table 5 Effects of maternal feeding of goats with low and high energy and protein diets on biometric traits of kids at 10, 20, and 28 d after birth

| | Treatments | | | | SEM | P-value | | |
|---|---|---|---|---|---|---|---|---|
| Energy | Low | | High | | | | | |
| Protein | Low | High | Low | High | | Protein | Energy | Protein × energy |
| **Biometric traits** | | | | | **10 d after birth** | | | |
| BW (g) | 3848.5[ab] | 4360.7[a] | 3645.0[b] | 3901.4[ab] | 98.29 | ** | NS | NS |
| WH (cm) | 37.33 | 39.71 | 36.28 | 37.14 | 0.9566 | NS | NS | NS |
| BL (cm) | 30.417[ab] | 34.429[a] | 30.857[ab] | 30.000[b] | 0.6517 | NS | NS | ** |
| HG (cm) | 17.00[b] | 18.42[a] | 17.85[a] | 16.85[b] | 0.2704 | NS | NS | * |
| SW (cm) | 6.50[ab] | 8.21[a] | 5.85[b] | 5.785[b] | 0.3227 | NS | * | NS |
| HW (cm) | 18.83 | 20.428 | 18.785 | 19.00 | 0.3247 | NS | NS | NS |
| RW (cm) | 9.833[ab] | 10.714[a] | 9.428[b] | 9.428[b] | 0.1780 | NS | * | NS |
| RL (cm) | 7.42 | 8.79 | 7.57 | 7.43 | 0.2181 | NS | NS | NS |
| | | | | | **20 dafter birth** | | | |
| BW (g) | 4688.31[b] | 5620.01[a] | 4432.11[b] | 4790.00[ab] | 144.99 | * | * | NS |
| WH (cm) | 40.91[b] | 43.64[a] | 40.42[b] | 41.28[b] | 0.3048 | ** | * | NS |
| BL (cm) | 35.08[b] | 38.28[a] | 32.50[b] | 34.35[b] | 0.5011 | * | ** | NS |
| HG (cm) | 18.83[ab] | 20.57[a] | 17.71[b] | 19.57[ab] | 0.3047 | * | NS | NS |
| SW (cm) | 6.92[b] | 8.57[a] | 6.00[b] | 6.86[b] | 0.2578 | * | * | NS |
| HW (cm) | 21.17 | 22.14 | 22.14 | 21.57 | 0.3303 | NS | NS | NS |
| RW (cm) | 9.75[b] | 11.21[a] | 9.64[b] | 10.29[ab] | 0.1989 | * | NS | NS |
| RL (cm) | 8.17[ab] | 8.43[a] | 7.79[b] | 8.43[a] | 0.0998 | * | NS | NS |
| | | | | | **28 dafter birth** | | | |
| BW (g) | 5380.00[b] | 6643.10[a] | 5107.90[b] | 5521.40[b] | 169.16 | * | * | NS |
| WH (cm) | 43.50 | 46.28 | 42.85 | 43.28 | 0.5776 | NS | NS | NS |
| BL (cm) | 36.17[b] | 40.71[a] | 34.57[b] | 34.79[b] | 0.4994 | * | ** | * |
| HG (cm) | 20.08[ab] | 21.71[a] | 19.28[b] | 20.36[ab] | 0.3245 | * | NS | NS |
| SW (cm) | 7.83 | 7.21 | 6.86 | 7.43 | 0.1670 | NS | NS | NS |
| HW (cm) | 23.17 | 24.28 | 22.64 | 23.28 | 0.3849 | NS | NS | NS |
| RW (cm) | 10.33 | 11.29 | 10.14 | 10.64 | 0.2084 | NS | NS | NS |
| RL (cm) | 8.50[b] | 9.50[a] | 8.57[b] | 9.00[ab] | 0.1402 | * | NS | NS |

BW: body weight; WH: withers height; BL: body length; HG: heart girth; SW: shoulder width; HW: head width; RW: rump width and RL: rump length.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.
NS: non significant.
* (P<0.05) and ** (P<0.01).

The association existing between biometric traits was observed to be strong (Table 5). Withers height and head width were similar between treatments at all time, however, both traits trend to be greater in treatment that had low energy but high protein concentration. Body length, heart girth, shoulder width, rump width, and rump length were different among treatments (Table 5). In general, growth performance and carcass traits have a medium to high heritability, while genetic progress in selection schemes is determined by genetic variation and co-variation among traits that are considered in the selection scheme, selection intensity, and generation interval. Birth weight of kids was corrolated with weight of second and fourth week. Weight of kids at second week was corrolated to weight of fourth week, consumed milk, and rump width.

Weight of kids at fourth week corrolated to heart girth and rump width. The consumed milk of kids significantly corrolated to body length. Withers height and heart girth corrolated to weight of kids at fourth week, and all of measured characterustics.

**Table 6** Correlation between body weight at birth, weights at second and fourth weeks of age, milk intak and some biometric traits of kids

| Item | BWK | WSW | WFW | MI | WH | HG | BL | RL | RW | HW | SW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BWK | - | 0.666 | 0.588 | 0.150 | 0.050 | 0.003 | 0.096 | 0.047 | 0.042 | 0.009 | -0.063 |
| WSW | 0.0002 | - | 0.917 | 0.427 | 0.270 | 0.359 | 0.223 | 0.347 | 0.390 | 0.157 | 0.217 |
| WFW | 0.0016 | < 0.0001 | - | 0.302 | 0.310 | 0.442 | 0.298 | 0.311 | 0.414 | 0.109 | 0.157 |
| MI | 0.4640 | 0.0296 | 0.1334 | - | 0.275 | 0.2697 | 0.418 | 0.348 | 0.3501 | 0.351 | 0.097 |
| WH | 0.8074 | 0.1811 | 0.1231 | 0.1735 | - | 0.781 | 0.630 | 0.612 | 0.713 | 0.579 | 0.473 |
| HG | 0.9862 | 0.0715 | 0.0236 | 0.1827 | < 0.0001 | - | 0.713 | 0.664 | 0.816 | 0.446 | 0.564 |
| BL | 0.6408 | 0.2732 | 0.1380 | 0.0332 | 0.0004 | < 0.0001 | - | 0.5200 | 0.6029 | 0.419 | 0.3065 |
| RL | 0.8192 | 0.0823 | 0.1216 | 0.0806 | 0.0007 | 0.0002 | 0.0054 | - | 0.597 | 0.447 | 0.246 |
| RW | 0.8357 | 0.0486 | 0.0354 | 0.0795 | < 0.0001 | < 0.0001 | 0.0009 | 0.0010 | - | 0.588 | 0.49778 |
| HW | 0.9644 | 0.4421 | 0.5949 | 0.0786 | 0.0015 | 0.0196 | 0.0293 | 0.0191 | 0.0012 | - | 0.338 |
| SW | 0.7598 | 0.2853 | 0.4424 | 0.6347 | 0.0126 | 0.0022 | 0.1199 | 0.2159 | 0.0082 | 0.0840 | - |

BWK: birth weightof kids; WSW: weight of second week; WFW: weight of fourth week; MI: milk intake; WH: withers height; HG: heart girth; BL: body length; RL: rump length; RW: rump width; HW: head width and SW: shoulder width.

Withers height and heart girth corrolated to weight of kids at fourth week, consumed milk, and all of measured characterustics. Also, shoulder width, head width, and rump width were correlated. Body measurements have been used in animals to estimate BW (Yakubu, 2010). Dorantes Coronado *et al*. (2015) reported that high correlations were found between heart girth and body length with live weight, this result suggests that producers who lack scales for weighing animals can estimate BW of their goats using either of those two zoometric measures; that is, they can use a tape rule instead of a weighing scale, a practice that is much easier to perform under field conditions. The use of heart girth as a reliable measure to predict BW in goats under field conditions, due to the fact that muscle, some fat, and bone structure contribute to its formation. Bello and Adama (2012) also found that heart girth was the best zoometric measure to predict BWin goats. Increasing the energetic density had a positive influence on the lambs' measured biometrics (Bandeira *et al*. 2016).

## CONCLUSION

The birth BW of kids was similar between the four treatment groups. The 7, 14, 21, 28 d, and in overall the BW and ADG of kids were greater in high protein treatments than other groups. Although the effects of energy were significant at 15-21 d and in overall of experiment but the interactions of protein and energy had not significant effect on the BW and ADG of kids. The CP concentration greater than NRC (2007) recommendation, increased the BW and ADG of kids at 7, 14, 21, 28 d, and in overall of experiment. However, energy concentration had no significant on the BW and ADG of kids. The present study has characterized the effects of maternal feed protein during mid-to-late gestation on the ADG of goats' kids. These prepartum maternal diets may be caused notable gene expression changes in fetal adipose and muscle tissues, and determination of the potential effects of these maternal diets on epigenetic modifications in the fetal genome from these tissues is needed in future studies. The BW of kids were different between treatments and LEHP ration had greater BW at birth, and 14, and 28 d of age. The results of the present study have practical implications not only for goat husbandry but also for the increased knowledge of nutrition that significantly influence variation in weight and biometric trait; as weight itself has become a significant predictor of later health outcomes.

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## REFERENCES

Abdel-Ghani A.A., Solouma G.M.A., AbdElmoty A.K.I., Kassab A.Y. and Soliman E.B. (2011). Productive performance and blood metabolıtes as affected by protected protein in sheep. *Open J. Anim. Sci*. **1,** 24-32.

Abdolvahabi S., Zaeemi M., Mohri M. and Naserian A.A. (2016). Age related changes in serum biochemical profile of Saanen goat kids during the first three months of life. *Rev. Med. Vet*. **167(34),** 106-112.

Annett R.W., Carson A.F. and Dawson L.E.R. (2008). Effects of digestible undegradable protein (DUP) supply and fish oil supplementation of ewes during late pregnancy on colostrums production and lamb output. *Anim. Feed Sci. Technol.* **146,** 270-288.

AOAC. (2002). Official Methods of Analysis. Vol. I. 17th Ed. Association of Official Analytical Chemists, Arlington, VA, USA.

Bandeira G.C., Campos A.C.N., Pereira E.S., Linard M.A.B., Castelo-Branco K.F., Evangelista M.E.S., Sousa D.L., Rios R.R.S., Montenegro A.R. and Gadelha C.R.F. (2016). Effects of different hay: concentrate ratios on body and testicularepididymal biometry and metabolic profile of Santa Ines lambs. *Ciên. Agrár. Lond*. **37,** 853-866.

Bandyk C.A., Cochran R.C., Wickersham T.A., Titgemeyer E.C., Farmer C.G. and Higgins J.J. (2001). Effect of ruminal vs.postruminal administration of degradable protein on utilization of low-quality forage by beef steers. *J. Anim. Sci*. **79,** 225-231.

Bell A.W. (1995). Regulation of organic nutrient metabolism during transition from late pregnancy to early lactation. *J. Anim. Sci*. **73,** 2804-2819.

Bello A.A. and Adama T.Z. (2012). Studies on body weight and linear body measurements of castrates and non-castrate Savan-nah Brown goats. *Asian J. Anim. Sci*. **6,** 140-146.

Choi S.H., Kim S.W., Park B.Y., Sang B.D., Kim Y.K., Myung J.H. and Hur S.N. (2005). Effects of dietary crude protein level on growth and meat quality of Korean native goats. *J. Anim. Sci. Technol*. **45,** 783-788.

Cottrill B., Dawson L., Yan T. and Xue B. (2008). A review of the energy, protein and phosphorus requirments of beef cattle and sheep. Defra Project WQ 0133. Available at: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Complete d=0&ProjectID=15958.

Dorantes Coronado E.J., Torres Hernández G., Hernández Mendo O. and Rojo Rubio R. (2015). Zoometric measures and their utilization in prediction of live weight of local goats in southern México. *Springerplus*. **4,** 695-695.

Dutta T.K., Agnihotri M.K., Sahoo P.K., Rajkumar V. and Das A.K. (2009). Effect of different protein-energy ratio in pulse by-product and residue based pelleted feeds on growth, rumen fermentation, carcass and sausage quality in Barbari kids. *Small Rumin. Res*. **85,** 34-41.

El-Shabrawy H.M. (2006). Performance of goats fed protected protein during gestation and lactation. *Egyptian J. Sheep, Goat. Desert. Anim. Sci*. **1,** 213-232.

Fernandez J.M., Lu C.D., Potchoiba M.J. and Loetz E. (1989). Dietary energy allowance and incidence of pregnancy toxemia in dairy goats. *Fed. Am. Soc. Exp. Biol. J*. **3,** 1256-1262.

Fernandez J.M., Sahlu T., Lu C.D., Ivey D. and Potchoiba M.J. (1997). Production and metabolic aspects of non-protein nitrogen incorporation in lactation rations of dairy goats. *J. Small Rumin. Res*. **26,** 105-117.

Gao F., Hou X.Z., Liu Y.C., Wu S.Q. and Ao C.J. (2008). Effect of maternal under-nutrition during late pregnancy on lamb birth weight. *Asian-Australasian J. Anim. Sci*. **21,** 371-375.

Gardner D.S., Tingey K., Van Bon B.W.M., Ozanne S.E., Wilson V., Dandrea J., Keisler D.H., Stephenson T. and Symonds M.E. (2005). Programming of glucose-insulin metabolism in adult sheep after maternal undernutrition. *Am. J. Physiol. Regul. Integr. Comp. Physiol*. **289,** 947-954.

Hatfield P.G., Snowder G.D.H.J., Glimp W.A., Stobart R.H. and Besser T. (1995). Production by ewes rearing single or twin lambs: Effects of dietary crude protein percentage and supplemental zinc methionine. *J. Anim. Sci*. **73,** 1227-1238.

He Z.X., Sun Z.H., Beauchemin K.A., Yang W.Z.S., Tang X., Zhou C.S., Han X.F., Wang M., Kang J.H. and Tan Z.L. (2015). Effect of protein or energy restriction during late gestation on hormonal and metabolic status in pregnant goats and postnatal male offspring. *J. Anim. Sci*. **9,** 1843-1851.

Hwangbo S., Choi S.H., Kim S.W., Son D.S., Park H.S., Lee S.H. and Hwan Jo I.K. (2009). Effects of crude protein levels in Total Mixed rations on growth performance and meat quality in growing Korean black goats. AsianAust. *J. Anim. Sci*. **22,** 1133-1139.

Kaneko J.J., Harvey J.W. and Bruss M.L. (2008). Carbohydrate metabolism and its diseases. Pp. 45-80 in Clinical Biochemistry of Domestic Animals. Academic Press, San Diego, California.

Larson D.M., Martin J.L., Adams D.C. and Funston R.N. (2009). Winter grazing system and supplementation during late gestation influence performance of beef cows and steer progeny. *J. Anim. Sci*. **87,** 1147-1155.

Long N.M., Prado-Cooper M.J., Krehbiel C.R., DeSilva U. and Wettermann R.P. (2010). Effects of nutrient restriction of bovine dams during early-gestation on postnatal growth, carcass and characteristics, and gene expression in adipose tissue and muscle. *J. Anim. Sci*. **88,** 3251-3261.

Muhlhausler B.S., Adam C.L., Findlay P.A., Duffield J.A. and McMillen I.C. (2006). Increased maternal nutrition alters development of the appetite-regulating network in the brain *FASEB J*. **20,** 1257-1259.

Murniati T., Idrus M., Rahardja D.P., LatiefToleng A. and Ako, A. (2013). Effect of maternal nutrition at different stages of pregnancy in goats (Etawa Cross and Kacang) on performance of does and goat kids. *Int. J. Sci. Res*. 6, 14-21.

Negesse T., Rodehutscord M. and Pfeffer E. (2001). The effect of dietary crude protein level on intake, growth, protein retention andutilization of growing male Saanen kids. *Small Rumin. Res*. **39,** 243-251.

NRC. (2007). Nutrient Requirements of Dairy Cattle. 7th Ed. National Academy Press, Washington, DC, USA.

Nuno A.R., Gomez J.J.U., Hernandez J.R.O., Hernandez V.O.F., Occidente A.D., DeCV S.A., Morelos T. and Mexico J. (2009). The effect of different protein concentrations in the diet of fattening Dorper and Pelibuey lambs. *J. Anim. Vet. Adv*. **8,** 1049-2051.

Radunz A.E., Fluharty F.L., Day M.L., Zerby H.N. and Loerch S.C. (2010). Prepartum dietary energy source fed to beef cows; I. Effects on pre- and postpartum cow performance. *J. Anim. Sci*. **88,** 2717-2728.

Radunz A.E., Fluharty F.L., Susin I., Felix T.L., Zerby H.N. and Loerch S.C. (2011). Winter-feeding systems for gestating sheep II: effects on feedlot performance, glucose tolerance, and carcass composition of lamb progeny. *J. Anim. Sci*. **89,** 478-488.

Radunz A.E., Fluharty F.L., Lowe G.D. and Loerch S.C. (2012). Effects of protein intake in late gestation beef cows on progeny postnatal growth and carcass traits. *J. Anim. Sci*. **90,** 122.

Rusche W.C., Cochran R.C., Corah L.R., Stevenson J.S., Harmon D.L., Brandt R.T. and Minton J.E. (1993). Influence of source and amount of dietary protein on performance, blood metabolites, and reproductive function of primiparous beef cows. *J. Anim. Sci*. **71,** 557-563.

Sahlu T., Hart S.P., Le-trong T., Jia Z., Dawson L., Gipson T. and The T.H. (1995). Influence of prepartum protein and energy concentrations for dairy goats during pregnancy and early lactation. *J. Dairy Sci*. **78,** 378-387.

SAS Institute. (2002). SAS®/STAT Software, Release 9.1. SAS Institute, Inc., Cary, NC. USA.

Shahjalal M., Bishwas M.A., Tareque A.M.M. and Dohi H. (2000). Growth and carcass characteristics of goats given diets varying protein concentration and feeding level. *Asian-Australasian J. Anim. Sci*. **13,** 613-618.

Sharifi M.A., Naserian A. and Rahimi A. (2014). Different levels of protein by dietary addition of cottonseed meal on the performance of Iranian Sannen kid. Pp. 23-26 Proc. 16th AAAP Anim. Sci. Congr. Gadjah Mada University, Yogyakarta, Indonesia.

Van Soest P.J., Robertson J.B. and Lewis B.A. (1991). Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. *J. Dairy Sci*. **74,** 3583-3597.

Vonnahme K.A. and Lemley C.O. (2012). Programming the offspring through altered uteroplacental hemodynamics: how maternal environment impacts uterine and umbilical blood flow in cattle, sheep, and pigs. *Reprod. Fertil. Dev*. **24,** 97-104.

Yakubu A. (2010). Path coefficient and path analysis of body weight and biometric traits in Yankasa lambs. *Slovak J. Anim. Sci*. **43,** 17-25.