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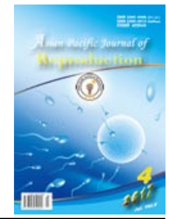

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Relationship between pre-pubertal nutrition plane with reproduction performance and milk quality in Kurdish female kids

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ABSTRACT

Objective: To investigate the reproductive performance and milk quality to nutrition pre-pubertal plane in Kurdish female kids. **Methods:** Forty Kurdish female kids [aged (28.0±6.6) d and weighted (7.56±1.10) kg] were assigned randomly in pre-weaning period to one of two practical diets: low quality diet (LQD) [87 g CP/kg dray matter (DM) and 2.02 Mcal ME/kg DM], and high quality diet (HQD), (148 g CP/kg DM and 2.50 Mcal ME/kg DM). At weaning, from each group, one half of kids was separated randomly and allocated to LQD or HQD. Consequently, in post-weaning period, there were four treatment groups including: LQD pre and post-weaning (L-L), control group and LQD pre-weaning and HQD post-weaning (L-H); HQD pre-weaning and LQD post-weaning (H-L), HQD pre- and post-weanin (H-H). From 30 to 180 d of age, body weight and DM intake were determined every 2 wk. **Results:** Results showed that the HQD treatment enhanced body weight and DM intake during pre-weaning period, in comparison with the LQD treatment (P<0.01). During post-weaning, kids of H-H treatment had higher DM intake compared with other kid's treatments. Kids fed the HQD treatment had greater withers height compared to kids on the LQD treatment at 90 d of age (P<0.01). Kids in the L-H and H-H groups weighed more and were younger at puberty. In the period of pre-pubertal, diet plan was not significantly affected milk yield and reproductive performance at the first lactation. **Conclusions:** Overall, management strategies that have been used to availability of nutrition could increase growth and feed intake in Kurdish female kids. In addition, these strategic programs should be enhancing economic characteristics at the start of puberty of kid in goat husbandry.

1. Introduction

In semi-arid, arid and tropical areas, animal production would be highly reliant on supplemental feeding, particularly during expensive reproductive seasons[1]. In west of Iran, goats have been proved to perform well under extensive, semi-intensive as well as intensive management systems. In these climates it is often difficult to meet these requirements because quantity and quality of forage varies with season, and can be scarce during dry-seasons. Therefore, they are economically important mainly on account of their short gestation period, generation interval and high prolificacy. Especially, the optimal reproductive performance undoubtedly would have a crucial role in intensive goat breeding in Zagros Mountains. During the goats' productive life, for both animal health and performance puberty period is highly important. The puberty onset in goat is influenced by environmental and genetic factors like day length, nutrition, breed, temperature, breeding technology, and their interaction. In a closed space, with respect to economic feasibility goats, one approach is manipulating the puberty age. For accelerating the goat kid maturity, farmers must change the traditional nutrition. However, because of the high positive correlation between body weights (BW) and kid morality would be required to apply supplementary strategies. Reproduction becomes possible, when the ewe lambs obtained 50%-70% of the adult weight. Weight gain includes two muscle and fat tissues and the activities of fat will be affected by nutrition[2]. Due to the live weight importance, the factors like before and after weaning weight gain crucial factors in determination of age at puberty[3]. Utilization of diet with high energy and protein increased plasma concentrations of leptin in ewe lambs[3,4]. If in the first autumn, a kid could not achieve puberty, until the next breeding season, it will be delayed[5,6].

Most livestock milk produced in the world is processed into cheese, yogurt and other dairy products. For this reason, the relationship between ewe nutrition and milk quality is mainly evaluated in terms of its technological and coagulation properties[7,8]. From lactation studies, the indirect evidence in ewe lambs proposes that before and after the main allometric growth phase, continuous rapid growth may depress mammary development as compared to feeding regimes including minimum one phase of limited feed intake[3,9,10]. Certainly, this subject could explain higher milk production of ewe lambs that fed lower energy and protein at 30-120 d of age[3].

Although studies into nutritional needs and the correlation between reproductive performance, nutrition, and milk production of animals have increased in recent years, more data would be required as the results have been contradictory. To the authors' knowledge, there are

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limited reports on the influence of nutrition on milk production and reproduction response in Kurdish female kids. Hence, our objective was to determine effects of survey of correlation between nutrition pre-pubertal plane with reproduction efficiency and milk production quality in the west of Iran.

2. Materials and methods

2.1. Hormonal drugs

A progestagen analogue (InterAg, Hamilton, New-Zealand), controlled internal drug release (CIDR) with 300 mg of progesterone, and pregnant mare serum gonadotropin (PMSG) (folligon; Intervet International B.V., Boxmeer, the Netherlands) were used.

2.2. Animals, diets, experimental design, and management

This research was carried out from January 2013 to December 2015, at Nomadic Management Department, Ilam Province, Iran (33º51´ N, 46º 27´ E). In this study, a total of 40 clinically health Kurdish female kids [weighing (7.56±1.10) kg and (28.0±6.6) d] were considered. Kids were randomly housed together with at 30 d of age and twice daily access to their mother milk and during two consecutive periods were assigned to one of two practical treatments to obtain either low or high rates of BW gain, from 30 to 90 d (pre-weaning period) and from 91 to 180 d of age (post-weaning period). For 3 consecutive days, they were kept in individual pens (1 m$\times$2 m) every 2 wk in order to record dry matter intake (DMI).

The kids fed low quality diet (LQD, n = 20) or high quality diet (HQD, n = 20) in pre-weaning period and at the weaning time LQD and HQD fed kids were re-randomized. Consequently, from each group, one half of kids randomly assigned to LQD or HQD. Therefore, in post-weaning period, there were four treatment groups (n = 10) including: LQD pre- and post- weaning (L-L, control group); LQD pre- weaning and HQD post- weaning (L-H); HQD pre- weaning and LQD post- weaning (H-L); HQD pre- and post-weaning (H-H). The LQD and HQD were formulated for small ruminants based on nutrient needs[9] suggestions that received a diet covering nutrient needs including protein and energy requirements for a 20-kg growing kid with an average of 200 and 100 g/d daily gain, respectively.

To have various crude protein (CP) content and metabolize energy (ME), diets were formulated. The LQD and HQD were included 14.9% and 8.9 % CP (DM basis) and 2.50 and 2.02 Mcal ME /kg DM, respectively. In pre- and post-weaning period, rations were totally hand-mixed for each pen and offered twice daily at 09:00 and 16:00 in equal proportions. Chemical composition and ingredient of the experimental diets can be seen in Table 1.

Table 1
Ingredient and chemical composition of experimental diets.

Composition (%)	Experimental diets	
	HQD	LQD
Alfalfa hay	445.1	-
Wheat straw	-	513.70
Ground barley	445.1	428.10
Soybean meal	59.3	-
Calcium carbonate	5.9	6.80
Salt	5.0	5.00
Mineral and vitamin premix*	39.6	46.40
DM	916.0	919.00
CP	148.0	87.00
EE	58.0	22.00
NDF	285.0	450.00
NFC	466.0	371.00
ME (Mcal/kg)	2.5	2.02

*Each kg (DM basis) of mineral and vitamin premix contained 180 g of Ca, 70 g of P, 35 g of K, 50 g of Na, 58 g of Cl, 30 g of Mg, 32 g of S, 5 g of Mn, 4 g of Fe, 3 g of Zn, 300 mg of Cu, 100 mg of I, 100 mg of Co, 20 mg of Se, 400 000 IU vitamin A, 100 000 IU vitamin D3, and 245 IU vitamin E. EE = Ether extract; NFC = Non-fiber carbohydrates = 100 – (CP+NDF+EE+ash); ME = Metabolite energy.

Estrus was induced and synchronized by CIDR when goat kids reached 180-d-old. For 14 d, animals were treated with CIDR and at the time of CIDR withdrawal, they were injected with 500 IU PMSG. All of goat kids were monitored for 24 h after CIDR withdrawal, for detection of estrus using 5 intact fertile bucks and were finally naturally bred. Until the estrous termination signs, the bucks remained with the goat kids. All goat kids were kept together after serving in the same managerial and nutritional conditions and until 2 wk before expected parturition reared in the pasture. At 60 d after serving, by using of trans-abdominal ultrasound (Piemedical, Falco 100; Netherlands), diagnosis of pregnancy was determined.

2.3. Procedures of sampling and measurements

From 30 to 180 d of age, the BW, hip width (HW), and wither height (WH) were measured every 2 wk. HW was characterized by tape measure, and WH was using of vertical graduated rod. Individual pens' feed offered and feed refusals were weighed and recorded daily and total mix ration and orts DM content were evaluated to predict CP and DMI. ME intake were obtained as DMI from each diet multiplied by their CP and ME contents, respectively[11]. Experimental diets' DM, CP and ether extract were evaluated based on the AOAC methods[12]. The neutral detergent fiber was determined based on the method explained by Van Soest *et al.*[13] without sodium sulfite and α -amylase and was described exclusive of residual ash. Considering National Research Council[11] dairy cattle model, non-fibrous carbohydrates content was determined as 100-(CP + neutral detergent fiber + ether extract +ash). Milk intake by goat kids was determined in 3 consecutive days every 2 wk by the weigh-suckle-weigh method from the beginning of study to weaning (30-90 d). At each suckling occasion (twice daily), at the beginning of weigh-suckle-weigh method, goat kids were weighed, permitted to suckle the udder of their dams and immediately after suckling weighed again. As milk intake, the difference between pre- and post-suckling weights was considered[14]. Goat kids were hand milked twice daily after kidding and throughout milk yield and lactation for the entire lactation (2 mo) was recorded at each milking. On each milking occasion, after intravenous injection of 1 IU synthetic oxytocin goats were milked by hand. In subsequent lactation, milk samples of dams and goat kids were collected every 2 wk in 3 consecutive days and using Milk-O-Scan 133B (Foss Electric, Hillerod, Denmark) evaluated for fat, protein and lactose. Milk fat, protein and lactose yields were determined by multiplying milk yield from the respective day by milk fat, protein and lactose contents for each goat. Milk gross energy (GE) was obtained using GE = [(0.054 7 $\times$ CP %) + (0.092 9 $\times$ Fat %) + (0.039 5 $\times$ Lactose %)] based on National Research Council[15]. The goat milk GE' mean metabolize ability was 0.94[16], consequently, milk ME content was obtained as GE $\times$ 0.94. Fat corrected milk (6.5% FCM) and energy corrected milk (ECM) were determined as FCM = Milk yield $\times$ [0.370 + (0.097 $\times$ Fat %)] and ECM = (0.327 $\times$ kg milk) + (12.950 $\times$ kg fat) + (7.200 $\times$ kg protein).

2.4. Statistical analyses

Applying the mixed model procedure of SAS software, the data of pre-weaning parameters were subjected to statistical analysis by using of completely randomized design (CRD) and post-weaning data were analyzed as a CRD in factorial arrangement (2$\times$2)[17] with fixed influences of treatment and kid nested random effects in treatments.

(1) $Y_{ik} = \mu + D_i + Lk\ (D_i) + \varepsilon_{ik}$

Y_{ij} = dependent variable

μ = mean

D_i = fixed influence of dietary treatment i

$Lk\ (D_i)$ = kid k nested effect in the dietary treatment

ε_{ik} = error

For repeated measure data, the model was:

(2) $Y_{ijk} = \mu + D_i + Time_j + D_i \times Time_j + Lk(D_i) + \varepsilon_{ijk}$

$Time_j$ = influence of time j as a fixed influence

Measurements performed before dietary treatments administration was applied as covariates. Starting with the least significant, the covariates were eliminated from the model one at a time. Mean±SE has been reported. When P<0.05, statistical differences were considered significant and when P<0.01 trends are discussed.

3. Results

Table 2 indicates body and skeletal growth and feed intake (as calculated by BW, WH and HW) measurements by treatment between 30 and 90 d age. Results showed that the HQD treatment successfully increased skeletal and body growth (longitudinal dimensions) rates and DM intake, in comparison with the LQD treatment during pre-weaning period (P<0.01). Although at weaning time, there were no differences among treatments in HW. During post-weaning (Table 3), H-H treatment kids had higher BW, skeletal growth rates and DM intake in comparison with other kid's treatments (P<0.01), but from 90 to 180 d of age, there were no differences between H-L and L-H groups (P<0.01). Throughout this time, BW and skeletal growth rates of L-H treatment were higher than H-L treatment numerically (P>0.05). Age at the puberty time was influenced by treatments (P<0.05). In addition, kids in the H-H and L-H groups were younger and weighed more at puberty. In addition, kids in the H-H and L-H groups were younger and weighed more at puberty. Thus, puberty age seemed to be similar in L-L and H-L treatments. Lack of diet effect (body condition) on H-L group puberty age did not seem to be due to pre-weaning diet quality, but it depends on the use time of high quality diet.

Table 2
Effect of pre-weaning plane of nutrition on intake, body and skeletal growth (mean±SE) of Kurdish female kids (30-90 d of age, n = 20).

Item		Pre-weaning treatments	
		HQD	LQD
DM (kg/d)		0.568±0.070	0.432±0.08*
FM (kg/d)		1.242±0.220	1.357±0.190
BW (kg)	30 d	7.620±1.100	7.510±1.200
	90 d	15.320±1.000	12.030±1.100*
WH (cm)	30 d	45.300±2.000	46.100±1.800
	90 d	58.600±1.900	54.400±1.700*
HW (cm)	30 d	15.700±0.800	16.000±0.900
	90 d	19.900±1.100	19.400±1.100

FM: Fresh milk. *: compared with HQD group, difference was significant (P<0.01).

Table 3
Effect of post-weaning plane of nutrition on intake, body and skeletal growth (mean±SE) of Kurdish female kids (180 d of age, n = 10).

Item	Post-weaning treatments			
	H-H	H-L	L-H	L-L
DM (kg/d)	0.997±0.080	0.840±0.110	0.806±0.120	0.776±0.090
PA (d)	107.000±12.000	155.500±25.000	128.500±14.000	163.500±17.000
BW (kg)	25.700±0.900	22.700±1.300	23.400±1.500	18.600±1.200
WH (cm)	66.000±1.200	62.200±2.000	63.400±2.300	57.400±1.500
HW (cm)	26.000±1.400	23.100±1.700	24.600±1.600	21.200±1.300

PA: Puberty age.

The pregnant goat number (pregnancy rate) L-L, L-H, H-L and H-H treatment was 70%, 100%, 80%, and 100% respectively (Table 4). Among treatments in pregnancy length and kid birth weight, there were no significant differences. The incidence of reproductive abnormalities was higher in H-L sequence in comparison with other treatments. Due to the limited numbers of kids could not effectively be incorporated into the statistical model for stillbirth and dystocia data.

Table 4
Effect of post-weaning plan of nutrition on reproductive performance (mean±SE).

Item	Treatments			
	H-H	H-L	L-H	L-L
Number of pregnant goat (n=10)	10	8	10	7
Birth Weight (kg)	3.05±0.20	3.47±0.40	3.28±0.20	3.25±0.30
Pregnancy length (d)	148.80±5.00	148.30±7.00	148.20±4.00	149.3±5.00
Stillbirth	1 (10)	2 (8)	1 (10)	1 (7)
Dystocia	3 (10)	4 (8)	4 (10)	3 (7)

In the pre-pubertal period, diet plan was not significantly affected colostrum yield (P>0.05, Table 5). First lactation milk yields and quality of milk had not change among treatments (P>0.05), however in pre-weaning period, milk yield of kids fed LQD produced numerically more milk.

Table 5
Effect of treatments on colostrum yield, milk quality and composition (mean±SE) in Kurdish female kids.

Item	Treatments			
	H-H	H-L	L-H	L-L
Milk yield (kg/d)	1.73±0.15	1.50±0.19	2.17±0.27	1.77±0.13
Colostrum (mL)	550.00±97.00	534.00±115.00	620.00±142.00	480.00±95.00
Fat (%)	4.02±0.16	3.78±0.18	3.91±0.21	3.80±0.16
Protein (%)	3.88±0.08	3.76±0.14	3.71±0.17	3.92±0.09
Lactose (%)	4.35±0.05	4.28±0.06	4.10±0.02	4.31±0.05
FCM 6.5% (g/d)	1.31±0.12	1.10±0.18	1.63±0.17	1.31±0.11
ECM (kg/d)	1.95±0.15	1.63±0.22	2.39±0.19	1.95±0.15

4. Discussion

4.1. Reproduction and growth

Animals reproductive performance is affected by a range of external factors, including socio-sexual cues, photoperiod and energy balance, age and breed. Reproduction is very energetically demanding, energy balance is arguably the next most powerful regulator of reproductive function. Variation in the level of nutrition (and changes in energy balance) can affect the reproductive cycle at almost any stage[2–4].

The reproductive abnormalities incidence was higher in H-L sequence compared with other treatments, and may be because of the higher kids' birth weight of this treatment. Age at first parturition, age at puberty, at a younger age spending successful and safe parturition, optimal nutrition; stress, breed and geographical region are important characteristics relevant to overall reproductive efficiency. In overall, taking the results together suggests that by the effective nutrients utilization, productivity of goats is fostered which is possible with a sufficient energy supply.

Animals of H-H sequence indicated their case dystocia, with regard to kids' low birth weight despite of good HW of their dams, that the possible cause should be searched at the future study. Some reports indicated the supplementation with energy rich and/or protein rich diets exerts a significant effect on reproductive function in ruminants by affecting follicular development, ovulation rate and pregnancy rate[18,19]. These findings are consistent with the results of current studies. The authors suggested that these feed sources may supply the protein and energy needs for reproduction, but can include plant secondary compounds affecting different components of the reproductive cycle that must be explore in future study.

The nutrition action on reproduction is thought to be mediated by different physiological pathways. Various studies have shown that in small ruminant (sheep and goats) variations in energy balance, defined as the difference between the pool of disposable energy and the pool of expended energy, can influence any of the three levels of the reproductive axis (hypothalamus, pituitary gland, gonads) and also impact on regulatory feedback mechanisms[1,4,20]. And also, Jaborek *et al.*[18] recommend that availability of energy has a key role on reproductive efficiency, because of the reproductive axis sensitivity to the adequacy of stores and nutrition of metabolic reserves.

Results of the current study showed that the kids fed the HQD would gain faster compared to kids fed the LQD in both skeletal size and body weight. The theory was later confirmed by Mahgoub *et al.*[21] who documented an evaluated three concentrations of dietary ME of 2.10, 2.38 and 2.68 Mcal/kg DM and revealed a positive influence of increased energy supplementation on BW of Dhofari and Omani Batina goats. During post-weaning period, H-L group skeletal growth rate was lower than L-L group, but final H-L sequence skeletal size was higher than L-L sequence, indicating the importance of pre-weaning nutrition plane. Our results indicated that more than 80% of pre-pubertal skeletal growth to maturity can be pre-weaning period. Regarding the higher skeletal growth rate, responses to quality of diet are dependent on various parameters including the animal capacity to skeletal growth (mineral deposits and protein synthesis), the diet and protein quality considering to satisfy the mineral and amino acid requirement of animal for increased bone synthesis[3]. Our experiment results, in addition to energy and protein supply (quality of diet), skeletal growths might be relevant to the application of alfalfa in HQD treatment. Since the mineral and protein deposition rate decreases with age, the response of protein will reduce as the animal matures. According to the results of the present study the HQD diet was effective during the early parts of the study but less effective as the kids matured. It was seen that skeletal compensatory growth during post-weaning period for losses caused by poor nutrition can be compensated during this period.

A part from the HW, is the same for other sizes? The rate of pre-weaning skeletal growth is approximately more than three times the rate of growth after weaning. Some factors such as shoulder width and shoulder height grow at a slower rate compared to body length, while these linear body measurements are also highly correlated with live weight[6]. According to the results of the current study, it seemed that there was a positive relation between nutrition and puberty. Results indicated that kids in the L-H and H-H groups weighed more and were younger at puberty.

4.2. Milk

A more complete understanding of nutritional regulation of milk secretion would contribute to the feeding and management practices development for altering milk composition and optimizing milk production[8,22]. Thus, one of the main objectives of this study was to determine effects of survey of relationship between pre-pubertal planes of nutrition with milk quality in Kurdish female kids in the west of Iran.

Utilization of high energy diet has been shown to reduce the mammary parenchymal growth in replacement heifers[23] and ewe lambs[24,25] and is in agreement with current results, while milk protein concentration did not differ. In this reason, the HQD probably had high energy and increased mammary fat pad during the pre-weaning period (mammary allometric growth phase) and depressed mammary tissue secretion[25]. Also, Capuco *et al.*[10] reported that pre-pubertal dietary protein and bST supplementation have often resulted in no effects on milk yield and composition of dairy heifers. Synthesis of milk fat shows a major energy cost for production of milk and plays a key role in determining the quality of dairy product and the energy partitioning into milk[25,26]. A contrary with this fact, results the current study showed that use of pre-pubertal nutrition plane could not improve milk fat synthesis. For future additional studies including more animals are required.

In general, enough skeleton size is needed to minimize kid morality during the parturition in Kurdish female kids in the west of Iran. And also, based on the results of present research, nutrition is probably the most important factor that impacts milk yield, especially in the first months of lactation. Further studies, including an analysis of economical profitability are necessary to define the optimal levels of energy to use in pre-pubertal plane of nutrition under various productive conditions, therefore to give the best suggestions to goat producers. WUE in comparison to their non-treated counterpart.

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Conflict of interest statement

The authors declare that they have no conflict of interest.

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