Lactation Performance of German Fawn Goat in Relation to Feeding Level and Dietary Protein Protection

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ABSTRACT : Effects of high and low levels of feeding with or without protected protein on the performance of lactating goats were studied. Twenty four German Fawn goats either from 1st (43.37±3.937 kg and 2 year old) or 3rd 62.64±6.783 kg and 4-5 year old) parity were used for the trial. Feeding levels were 7.2 (I) and 5.2 (II) MJ ME/litre of milk of 3.5% fat in addition to that of the maintenance allowance. At each feeding level, diet had either unprotected (U) or formaldehyde protected (P) soya-meal. Thus, four diets were IU, IP, IIU and IIP, having six animals in each. The diets were composed of hay and pellet (10:4:1 of beet pulp : barley : soya-meal). Effect of feeding level, protein protection, parity, health status and kid number on intake, milk yield, milk composition, growth rate of goats were recorded across the 21 weeks of study. High feeding level resulted increase ($p<0.001$) in estimated metabolizable energy (ME) and metabolizable protein (MP) availability. Dietary inclusion of protected soya-meal increased ($p<0.001$) the estimated MP but not the ME availability. Animals in 1st parity ate more ($p<0.001$) DM (111 vs. 102 g/kg $W^{0.75}$/d) than those in 3rd parity. Animals with twin kids (110 g/kg $W^{0.75}$/d) had higher ($p<0.001$) DM intake than those with single kid (102 g/kg $W^{0.75}$/d). Fat (4%) corrected milk (FCM) yield was not effected by high (1,924 g/d) or low (1,927 g/d) feeding level but increased ($p<0.001$) with protected (2,166 g/d) compared with unprotected (1,703 g/d) soya-meal. FCM yield for four dietary combinations were 1,806, 2,078, 1,600 and 2,254 g/d for diets IU, IP, IIU and IIP, respectively. For unit increase (g) in estimated MP availability relative to ME (MJ) intake, FCM yield increased 1,418(±275.6) g daily ($r^2=0.58$; $p<0.001$). Milk fat (3.14 vs. 3.54%; $p<0.001$) and protein (2.94 vs. 3.04% $p<0.05$) contents were lower at high than the low feeding level. Protected protein increased ($p<0.001$) the fat, lactose and net energy (NE) content of milk. Milk urea concentration of 175, 183, 192 and 204 mg/l for diets IU, IP, IIU and IIP, respectively indicated lower RDP content of these diets. The RDP contents were 6.97, 6.70, 7.30 and 6.83 g/MJ of ME for diets IU, IP, IIU and IIP, respectively. Live weight change over the experimental period were 41, 6, 17 and 19 g/d. Absence of any positive response of high feeding was probably due to inefficient rumen fermentation resulting from inadequate RDP supply. Protected protein improved production performance apparently by increasing MP:ME ratio in the absorbed nutrient. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 2 : 222-237)***

Key Words : Goat, Feeding Level, Protected Protein, Intake, Milk Yield, Live Weight Chang

INTRODUCTION

The nutrient requirements for milk production are based on the metabolisable energy (ME) or similar systems, which were developed prior to the recognition of the requirements for metabolisable protein (MP). It is now known that feed stuffs containing protein may be utilised differently depending on the degradability of the protein in the feed. The requirements for protein in milk production depends on both the total protein available and the ratio of protein to non-protein substrate absorbed by the animal. In addition, the protein requirements relative to energy depend on the environmental conditions to which the animal is subjected. More protein relative to other nutrients is needed as the environmental conditions improve from animals being cold to animals entering their thermo-neutral zone. Thus in the tropics the diets of dairy cows need to yield higher levels of MP relative to energy substrates (Leng, 1990).

Even in the temperate areas the metabolic protein requirements for milk production in the goat have not been defined where the sources of dietary protein are often of unknown degradability and the total dry matter intake of lactating animals may fluctuate. Thus the ratio of MP in the metabolisable energy (ME) consumed is constantly changing.

As part of a study aimed at understanding the protein requirements of dairy animals with fluctuating total feed intake a feeding trial was undertaken to examine the effects of level of feed intake and level of MP supply on milk yield of German Fawn goats.

MATERIALS AND METHODS

Experimental animals and pre-experimental management

Twenty seven pregnant German Fawn goats were selected from the Institute herd. Fourteen were two years old and 43.4±3.9 kg live weight (non-pregnant weight), in their first pregnancy (1st Parity). Thirteen were 4-5 years old and 62.6±6.8 kg live weight (non-pregnant and non-lactating weight), in their third gestation (3rd Parity). All

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goats were mated in September 1999, and were housed in a loose housing stable. During early pregnancy they were each offered free choice of a diet of grass hay and pelleted concentrate (Type 047 for breeding sheep, 5.9 MJ ME/kg DM, 16% CP, 3% fat, 13% CF, 9.5% ash, 1.2% Ca, 0.5% P and 0.5 Na) in addition to 100 g sugar beet pulp. The concentrate was increased to 300 g/day during mid (October-November) and to 600 g/day in late (December) pregnancy. Approximately 2 weeks prior to kidding, they were transferred to individual cages (2×1.5 m) with straw bedding in an animal house. They were injected with 2 ml of vitamin D_3 intra-muscularly and offered a diet of *ad libitum* grass hay supplemented with 200 g concentrate pellets until they kidded.

Experimental design and feeding

Twenty four animals were used for the experiment. All animals received similar levels of maintenance energy (425 kJ ME/kg $W^{0.75}$/d) and protein (3.2 g crude protein/kg $W^{0.75}$/d) according to German (DLG, 1997) and International (NRC, 1981) standard. The goats were divided into two main groups on the basis of their milk yield. Group I (high level : I) received 7.2 MJ ME and 73.5 g CP, and Group II (low level : II) received 5.15 MJ ME and 60.02 g CP per litre of fat corrected (3.5%) milk. The groups were similar in total account of parity, body weight, milk yield to previous lactation and kid number (single or twin). Each group was then divided into two sub-groups of six animals. The two sub-groups were fed concentrate containing either unprotected soyabean-meal (U) or protected (3 g of 40% formaldehyde per kg of soya-meal) soyabean-meal (P). The experimental diet comprised of grass hay and pellets based on beet pulp, barley and soyabean-meal at the ratio of 10:4:1 (as fed). Thus four groups were

IU-High feeding level with unprotected soya-bean meal
IP-High feeding level with protected soya-bean meal
IIU-Low feeding level with unprotected soya-bean meal, and
IIP - Low feeding level with protected soya-bean meal

Experimental management

The animals were given equal amounts of feed twice daily after milking. Minerals were mixed with the pellets according to NRC (1981) to provide 2 g Ca and 2.1 g P per day for maintenance and 2 g Ca and 1.4 g P per litre milk of 4% fat. Individual feed offered and residue left was recorded daily. Feed refusals were poolled over 7 days and analysed for DM. Fresh water was available at all time. Goats were machine milked twice daily. Average milk production was calculated from the yields on three consecutive days in each week. Milk fat, protein, lactose and urea were determined twice in a week. Animals were weighed after kidding, then on a fortnightly basis only to reduce the handling stress. Blood was collected from jugular vein on 7th, 14th, 21st week of lactation at 0 (before), 2 and 4 h after feeding in the morning. Blood samples were centrifuged at 3,000 rpm for 10 min. and plasma was then collected and stored at -20°C until analysed.

Health status

A veterinarian examined the animals daily to identify any health problem. One animal from each of group IP and IIP were excluded paratuberculosis and acute mastitis, respectively. Besides, some animals had mild form of mastitis and paratuberculosis. One doe in group IU was suckling its own milk and was thus excluded from the trial. Somatic cell content of the milk was counted for monitoring incidence of mastitis. All animals received a dose of Ivomax for controlling the external parasite.

Chemical analysis

Samples of feed and refusals were analysed for DM, ash, crude protein and crude fibre according to Weende Analysis System. Feed DM was determined by oven drying at 105°C for 48 h. Ash was determined by incinerating 5 g of air-dried sample at 550°C for 16 h. Fibre was determined by Tecator Fibretech System (Model 1020 Hot Extractor). Nitrogen (N) was determined by the standard Kjeldhal method and the crude protein by N × 6.25. Milk samples were analysed for fat, protein, lactose and urea by using a mid infrared reflective spectroscopy by the Milk Testing Organization for Brandenburg (Landeskontrollverband Waldsieversdorf, Berlin). Plasma glucose and urea concentration were measured photometrically (Dr. Lange, CADAS 200) at 340 nm by enzymatic method using D-Glucoes UV Test Kit and urea/ammonia UV Test Kit (Firma Böhringer, Mannheim, Germany), respectively.

Estimation of nutrient availability

The amount of ME available from diet was estimated from sum of the ME content of individual feed ingredient ingested by an animal using the nutrient composition table (DLG, 1997). The amount of MP available was calculated the sum of microbial true protein (MTP) synthesized in the rumen plus dietary digestible protein escaping rumen degradation. MTP was estimated by assuming: 9.6 g microbial crude protein/MJ ME, 0.75 true protein in microbial protein and 0.85 true small intestine digestibility (AFRC, 1998). Dietary UDP of feed was estimated from sum of the UDP content of individual feed ingredient ingested by an animal using the nutrient composition table (DLG, 1997).

Estimation of nutrient requirement

Maintenance ME requirement was estimated as fasting energy cost of 315 kJ ME/kg $W^{0.75}$ daily plus 10% activity allowance, 5 kJ/kg for standing for 12 h and 3.12 kJ/kg for 12 position changes/d and efficiency of utilization of ME for maintenance of 0.74 (AFRC, 1998). The ME requirement for lactation estimated as milk net energy÷ 0.63 (efficiency of ME utilization for lactation, AFRC, 1998). The net energy (NE) content of milk was estimated according to Tyrrell and Reid (1965) as :

Milk NE (kcal/lb)=41.63(%fat)+22.29(%protein)+21.60 (%lactose) – 11.72.

The value was then expressed as NE MJ/kg milk. The ME requirement for live weight gain was estimated as

ME MJ/kg gain = 4.972 + 0.3274W;

where, W is the live weight of the animal and efficiency of ME utilization for live weight gain 0.479 (AFRC, 1998).

Maintenance MP requirement was estimated as 2.19 g MP/kg $W^{0.75}$/d (AFRC, 1998). The MP requirement for lactation was estimated from the true milk protein content of milk assuming efficiency of utilization of MP for lactation of 0.68 and taking true milk protein as 0.9 of crude protein (AFRC, 1998). The protein requirement for live weight gain was estimated as:

Protein (g/kg) = 157.22 - 0.694W

where, W is the live weight of the animal and efficiency of MP utilization for live weight gain 0.59 (AFRC, 1998).

Efficiency of nutrient utilization for milk

The efficiency of ME utilization for milk was estimated as:

(Amount of ME excreted in milk) ÷ (amount of ME excreted in milk + ME available for production).

Milk ME was estimated as : milk NE ÷ 0.63,

where, 0.63 is the efficiency of ME utilization for milk production (AFRC, 1998).

Available ME for production was estimated as :

total ME - ME for maintenance.

Similarly, efficiency of MP utilization for milk was estimated as:

(amount of MP excreted in milk) ÷ (amount of MP excreted in milk + MP available for production). Milk MP was estimated as : milk protein ÷ 0.68,

where, 0.68 is the efficiency of MP utilization for milk production (AFRC, 1998).

Available MP for production was estimated as : total MP - MP for maintenance.

Statistical analysis

The data were analysed by using univariate GLM procedure of SPSS 9.0 for Windows (SPSS Inc. 1998) statistical package. The main effects of the statistical model were feeding level (high or low), protein protection (protected or unprotected), parity (1st or 3rd), health status (category 1,2,3) and number of kids (single or twin) during the entire experiment. The entire experiment included average weekly data of intake, milk yield, milk composition, growth rate during 1-21 week of lactation. The model used was as follows

$$Y_{ijklm}=\mu+\alpha_i+\beta_j+\gamma_k+\delta_l+\pi_m+(\alpha\beta_{ij})+(\alpha\beta\gamma_{ijk})+e_{ijklm}$$

Here Y_{ijklm} is the observed value for a dependent variable on i^{th} feeding level (i=1,2), j^{th} protein protection (j =1,2), k^{th} parity (k=1,2), l^{th} health status (l=1,2,3) and m^{th} kid number (m=1,2) with μ is the general mean and e_{ijklm} as the random error. Reduced model was used for analysing the effect of lactation total or lactation phases on different parameters, pooled data across the lactation (whole or phase), by removing the non-significant independent variable.

Both live weight and milk production was regressed against time (week) using the linear regression model to obtain the slope that was then compared by using the same univariate general linear model. However, health status and kid number were not included as independent variable in the model. The later was done in order to increase the residual degree of freedom and thus improve the test efficacy. Linear and/or quadratic equations were fitted to obtain the nutrient responses of animals in terms of fat corrected milk yield at different stages of lactation.

RESULTS AND DISCUSSION

Feed quality

The chemical composition and the estimated ME and MP content of diets are given in table 1. These diets were adequate in fermentable energy (average, 11.38 MJ/kg DM) but low in rumen degradable protein (average 6.95 g RDP/MJ ME) relative to the ARC (1984) recommendation (7.81 g RDP/MJ ME). The extent of RDP deficiency was more severe at high feeding level (about 13%) than at low feeding level (about 10%). This means that there were inefficient microbial fermentation in all these diets and the higher the feeding level, the lower was the efficiency of microbial protein production

Intake

Weekly average DM (g/kg $W^{0.75}$/d), ME (MJ/kg $W^{0.75}$/d) and MP (g/kg $W^{0.75}$/d) of different groups of animals during 21 weeks of lactation are shown in figure 1. DM intake ranges between 82-145 g/kg $W^{0.75}$/d, which fall in the range of 47-181 g/kg $W^{0.75}$/d for temperate lactating goats (Sauvant et al., 1991). The overall intake trend is similar to the observation that intake rises curvilinearly just after parturition and reaches the maximum at about 6 week and then decreases linearly at the rate of 25 g/animal/week (Sauvant et al., 1991).

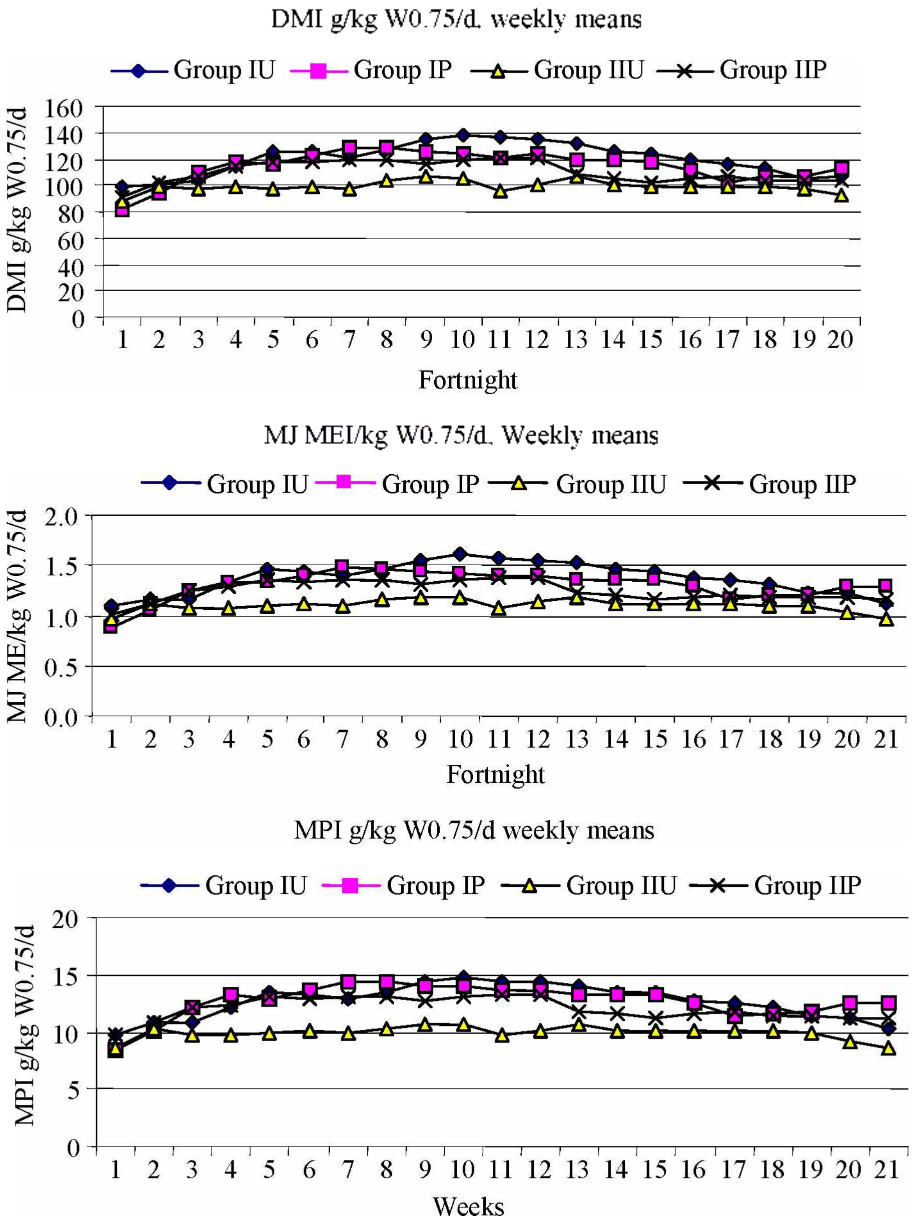

Figure 1. Average weekly DM, metabolizable energy, metabolizable protein of different groups of animals during 21 weeks of lactation. Each value represents mean of at least five animals

Effect of feeding level on intake

The effect of feeding level on intake of hay, pellet and total DM, ME and MP is shown in table 2. The obvious effect of higher level of feeding resulted significant ($p<0.001$) increase in total DM, ME and MP intake. However, average total DM intake even at high level of feeding (112 g/kg $W^{0.75}$/d) was slightly less than the AFRC (1998) suggested value (119.6 g/kg $W^{0.75}$/d).

The ME intake at low level of feeding (1.123 MJ/kg $W^{0.75}$/d) was about 2.55 times that of maintenance (0.441 MJ/kg $W^{0.75}$/d, AFRC, 1998). This level of intake can yield 3.12 litre 4% FCM (assuming 4.714 MJ ME/litre of 4% fat corrected milk, Sauvant and Morand-Fehr, 1991) daily by a 60 kg doe. Similarly, at high level of feeding, available ME (1.291 MJ/kg $W^{0.75}$/d) can yield 3.89 litre of 4% FCM. As we will see later that average FCM production was less than 2 kg in this trial. This means that energy supply was well in excess of requirement even in animals of low level of feeding. Thus, present German recommendation 8 MJ ME per litre of 4% FCM (DLG, 1997) appears to be an over estimate than its actual requirement.

High level of feeding resulted significantly ($p<0.001$) higher MP intake (12.2 g/kg $W^{0.75}$/d) than the lower level (10.5 g/kg $W^{0.75}$/d). This is probably due to higher estimated microbial protein contribution from higher fermentable energy intake in the former group of animals (ARC, 1984).

Effect of protected protein supply on intake

Effect of dietary inclusion of formaldehyde treated (protected) or raw (unprotected) soya-meal on daily intake of hay, pellet and total DM, ME and MP is shown in table 3. As expected, MP availability significantly ($p<0.001$) increased with formaldehyde treated soya-meal. This is due to higher availability of digestible UDP from protected soya-meal.

Total DM and ME intake was not affected by whether the diet was supplemented with protected or unprotected soya meal. This is different from the observation that supplementation of pre-weaned Damascus goat with formaldehyde treated soya-meal reduce feed intake of concentrate, lucerne hay and barley straw based diet by 12% over that of the untreated soya-meal (Hadjippanayiotou and Morand-Fehr, 1991). Similarly, formaldehyde treated soya-meal reduced DM intake by 16% in Alpine goats at mid lactation (Brun-Bellut et al., 1990). One possible reason for reduced DM intake in later cases could be due to lower rumen degradable protein (RDP) supply (RDP requirement (g) = 7.813 × ME intake, ARC, 1980) in the diets. In fact, in Brun-Bellut et al. (1990) trial, RDP supply was 29% lower in formaldehyde treated soya-meal group than the control. However, despite 13% lower RDP supply in protected soya-meal group of the present trial (about 6.7-6.83 g RDP/MJ ME), there was no depressing effect on DM intake. One possible reason could be that pellet (with smaller particle size) feeding in the present trial increased the outflow of digesta and thus had no negative influence of lower dietary RDP content (Gherardi et al., 1992; McSweeney and Kennedy, 1992; Mui et al., 2000).

Table 1. Chemical composition of hay and pellet and calculated metabolizable energy (ME) and Metabolizable protein (MP) content of diet offered during 21 weeks of lactation (units: g/kg DM unless stated)

Ingredients	I U	I P	IIU	II P
Hay				
DM	929.8	929.8	929.8	929.8
OM	927.2	927.2	927.2	927.2
CP	113.3	113.3	113.3	113.3
CF	283.3	283.3	283.3	283.3
MP	77	77	77	77
ME (MJ/kg DM)	9.69	9.69	9.69	9.69
NE (MJ/kg DM)	5.73	5.73	5.73	5.73
Pellet				
DM	900.4	899.6	900.4	899.6
OM	915.7	935.1	915.7	935.1
CP	123.9	128.9	123.9	128.9
CF	128.6	125.6	128.6	125.4
% CF in the total diet	16.70	17.27	19.04	17.98
% CP in total diet	12.32	12.38	11.92	12.21
%RDP in total diet	65.51	61.07	68.16	62.00
%UDP in total diet	34.49	38.93	31.84	38.00
Estimated RDP g/MJ ME intake in diet	6.97	6.70	7.30	6.83
Estimated total diet ME (MJ/kg DM)	11.58	11.41	11:19	11.32
Estimated total diet MP (g/kg DM)	106.24	111.09	100.66	108.91

Effect of energy-protein interaction on intake

Effect of energy-protein interaction on daily intake of hay, pellet and total DM, ME and MP is presented in table 4. Except hay, all the intake parameters based on metabolic weight basis, significantly ($p<0.001$) differ each other and the highest was with group IU followed by IP, IIP and IIU. Hay intake was inversely related with the pellet intake in all groups. This is probably due to negative substitution effect of lower pellet consumption on hay intake (Preston and Leng, 1987). The lowest performance was observed with animals of group IIU. This is due to lower dietary energy concentration and also due to lower MP availability from unprotected soya-meal. Figure 2 shows the effect of dietary ME (MJ/ kg $W^{0.75}$/d) concentration on intake of DM, ME and MP expressed as metabolic weight basis. Both DM and ME intake increased curvi-linearly with increased dietary ME concentration. Sauvant and Morand-Fehr (1991) showed similar response of increasing ME concentration on DM intake. However, the estimated MP availability showed quadratic response to dietary ME concentration at the

Table 2. Effect of feeding level on daily intake of hay, pellet and total DM and ME and MP based on metabolic body weight (kg $W^{0.75}$) basis over the whole experimental period

Parameter	Feeding level				Significance
	High	SE	Low	SE	
Hay DM intake (g/d)	26	0.45	34	0.52	***
Pellet DM intake (g/d)	86	1.33	66	1.52	***
Total DM intake (g/d)	112	1.36	100	1.55	***
ME intake (MJ/d)[a]	1.29	0.016	1.21	0.020	***
MP intake (g/d)[b]	12.19	0.160	10.47	0.183	***

[a,b] ME=Metabolizable energy and MP=metabolizable protein (see Materials & methods for detail). *** $p<0.001$.

highest level. This is due to lower MP supply from unprotected soya-meal at group IU.

Effect of parity on intake

Effect of parity (1st or 3rd kidding) on daily intake of hay, pellet and total DM, ME and MP is presented in table 5. Animals in 1st parity had significantly ($p<0.001$) higher DM, ME and MP intake than those in 3rd parity. This is probably due to higher live weight (mean weight : 58 vs. 46 kg) of the later group of animals. Sauvant et al. (1991) showed that DM intake of temperate lactating goat increases linearly up to 2 years (up to 55-60 kg) and then declines exponentially from three years onward (>60 kg). Lower ME and MP intake with heavier animals confirms the allometric relationship between the body size and intake; the higher the body size the lower the intake. Chilliard (1985) observed that pregnant and lactating goats with more body fat have a significant lower intake capacity. In this trial, heavier animals of 3rd parity must has higher body fat than the lighter animals of the 1st parity. Besides, a young growing animal have higher ME and MP requirement for maintenance than a mature adult animal (Ørskov and Hovell, 1986; Chowdhury, 1992). Thus, with same amount of nutrient intake, a mature animal has more available nutrient for productive function than a young growing animal. Thus, on a similar nutritional and management programme, a young animal eats more than an adult animal when expressed on similar weight basis.

Effect of litter size on intake

Effect of number of kid(s) born per doe at parturition on daily intake of hay, pellet and total DM, ME and MP is

Table 3. Effect of dietary inclusion of formaldehyde treated (protected) or raw (unprotected) soya-meal on daily intake of hay, pellet and total DM, ME and MP based on metabolic body weight (kg $W^{0.75}$) basis over the whole experimental period

Parameter	Soya-meal				Significance
	Unprotected	SE	Protected	SE	
Hay DM intake (g/d)	29	0.71	31	0.31	NS
Pellet DM intake (g/d)	76	1.29	76	1.59	NS
Total DM intake (g/d)	105	1.32	107	1.62	NS
ME intake (MJ/d)[a]	1.20	0.016	1.21	0.020	NS
MP intake (g/d)[b]	10.93	0.155	11.73	0.191	***

[a,b] ME=Metabolizable energy and MP=metabolizable protein (see Materials and methods for detail). *** $p<0.001$, NS=not significant.

Table 4. Effect of dietary energy and protein concentration on daily intake of hay, pellet and total DM, ME and MP based on metabolic body weight (kg $W^{0.75}$) basis over the whole experimental period

Parameter	Treatment combinations[1]								Significance
	IU	SE	IP	SE	IIU	SE	IIP	SE	
Hay DM intake (g/d)	25[d]	0.59	28[c]	0.56	35[a]	0.54	33[b]	0.74	***
Pellet DM intake (g/d)	91[a]	1.74	81[b]	1.60	60[d]	1.60	72[c]	2.17	***
Total DM intake (g/d)	116[a]	1.78	109[b]	1.73	95[d]	1.63	104[c]	2.21	***
ME intake (MJ/d)[#]	1.34[a]	0.021	1.24[b]	0.021	1.06[d]	0.020	1.18[c]	0.027	***
MP intake (g/d)[#]	12.28[a]	0.210	12.10[b]	0.204	9.57[d]	0.192	11.37[c]	0.262	***

[a,b,c,d] Values with different superscripts in the same row differ significantly; *** $p<0.001$.

[1] IU=High feeding level with unprotected soya-meal; IP=High feeding level with uprotected soya-meal; IIU=Low feeding level with unprotected soya-meal; IIP=Low feeding level with protected soya-meal.

[#] ME=Metabolizable energy and MP=metabolizable protein (see Materials and methods for detail).

Table 5. Effect of parity (1st or 3rd kidding) on daily intake of hay, pellet and total DM, ME and MP based on metabolic body weight (kg $W^{0.75}$) basis over the whole experimental period

Parameter	Parity				Significance
	1st	SE	3rd	SE	
Hay DM intake (g/d)	33	0.43	27	0.55	***
Pellet DM intake (g/d)	78	1.29	75	1.62	*
Total DM intake (g/d)	111	1.32	102	1.65	***
ME intake (MJ/d)[a]	1.25	0.016	1.16	0.020	***
MP intake (g/d)[b]	11.75	0.156	10.91	0.195	***

[a,b] ME=Metabolizable energy and MP=metabolizable protein (see Materials and methods for detail). *** $p<0.00$, * $p<0.05$.

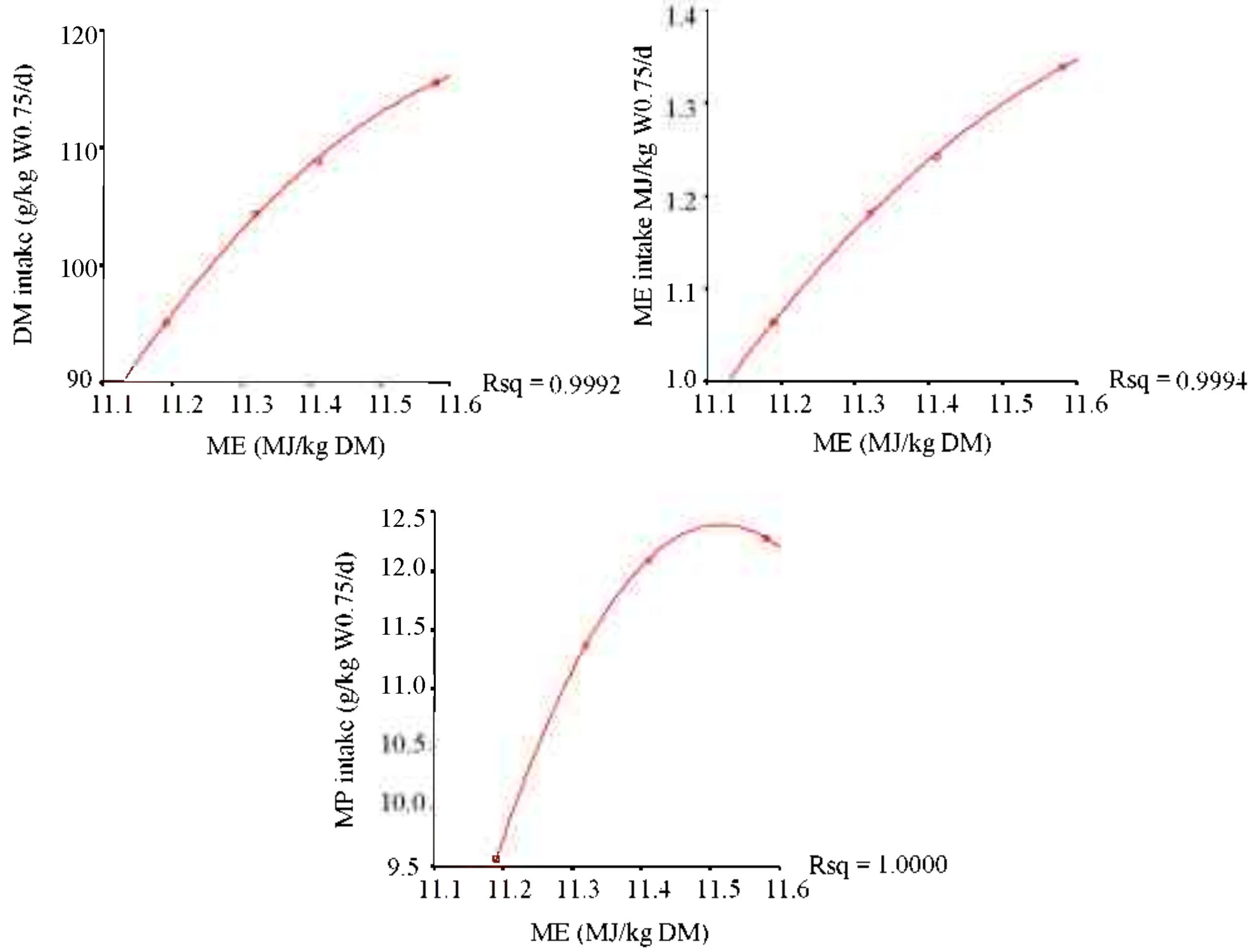

Figure 2. The effect of dietary metabolizable energy (ME) concentration (MJ/kg DM) on intake of DM (g/kg $W^{0.75}$/d) and availability of estimated ME (MJ/kg $W^{0.75}$/d) and metabolizable protein MP (g/kg $W^{0.75}$/d). Each point represents the mean of at least 5 animals, having 147 repeated measurements on each animal

shown in table 6. Animals with twin kid eat significantly higher DM ($p<0.05$), ME ($p<0.01$) and MP ($p<0.01$) than those having single kid. Energy and protein requirement of goat during pregnancy is related with the foetus weight over the course of gestation (Sauvant and Morand-Fehr, 1991; AFRC, 1998). In the present trail, average (±SD) birth weight of single and twine kid were 4.05(±0.63) and 3.56(±0.69) kg respectively. Assuming gravid uterus weight of 1.6 × litter weight (Sauvant and Morand-Fehr, 1991), a twin kid bearing animal had 11.39 kg of concepta compared to that of 6.48 kg for a single kid bearing animal. AFRC (1998) recommended 61% higher ME and 67% higher MP requirement for a twin than a single kid bearing doe. However, in this trial, during pregnancy, feed was offered at flat rate (ad libitum hay and 200, 300 and 600 g pellet during 1st, 2nd, 3rd and 4th month of lactation respectively)

Table 6. Effect of number of kid(s) born per doe at parturition on daily intake of hay, pellet and total DM, ME and MP based on metabolic body weight (kg $W^{0.75}$) basis over the whole experimental period

Parameter	Number of kids of doe				Significance
	Single	SE	Twin	SE	
Hay DM intake (g/d)	29	0.71	31	0.31	*
Pellet DM intake (g/d)	73	2.09	79	0.92	*
Total DM intake (g/d)	102	2.13	110	0.93	*
ME intake (MJ/d)[a]	1.17	0.026	1.25	0.11	**
MP intake (g/d)[b]	10.94	0.251	11.72	0.110	**

[a,b] ME=Metabolizable energy and MP=metabolizable protein (see Materials and methods for detail). ** $p<0.01$, * $p<0.05$.

without considering the litter size. Thus, twin-bearing animal must have mobilized their body reserve to meet higher nutrient demand for their heavier concepta. After parturition, these animals may have compensated by increasing their intake (Ryan, 1990). The mean PM intake in twin bearing animals (11.72 g kg $W^{0.75}$/d) was 7.13% higher than the single bearing animals (10.94 g kg $W^{0.75}$/d). This value is close to 9.26% higher MP intake by restricted sheep on re-alimentation (Kamalzadeh et al., 1997).

Milk yield

Average FCM yield of different groups of animals during 21 weeks of the experimental period is shown in figure 3. Except group IU, animals in other groups reached peak production within 1-2 weeks and then declined linearly. Rate of decline estimated as the slope of regression between FCM yield (g/d) vs. week, were (mean slope±SE) 57±18.3, 57±17.4, 55±15.3 and 84±18.3 g/week for group IU, IP, IIU and IIP respectively. The rate of decrease was non-significantly ($p=0.42$) higher with high yielding group. This type of lactation curve is similar to that of low milk yielding tropical goats (Djibrillou et al., 1998; Sangare and Pandey, 2000) but is different from dairy breeds which attain peak milk production during 6-8 weeks of lactation (French, 1970).

Fat corrected milk (FCM) yield in different groups of animals

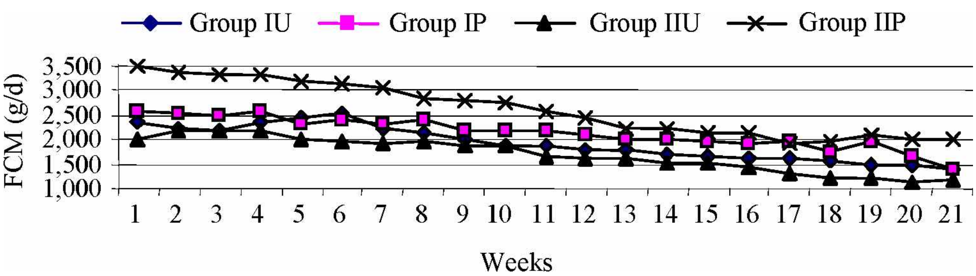

Figure 3. Average daily fat corrected (4%) milk yield of different groups of animals during 21 weeks of lactation. Each value represents mean of at least 5×3=15 observations

Figure 4 shows the weekly average milk fat, protein, lactose and urea content of different groups of animals during 21 weeks of lactation. Milk fat and protein content are the highest during 1st week and then declines gradually up to 7th week after that it remains stable over the lactation length. Similar phenomenon was also observed in dairy cow (Sutter and Beever, 2000) and goat (Sangare and Pandey, 2000). Milk lactose also gradually declined. Elevated milk urea was observed during mid lactation, but was lower at the beginning and at the end. Milk urea concentration is more related with dietary energy and protein content (Brun-Bellut et al., 1991), which will be discussed later.

Effect of feeding level on milk yield

Effect of feeding level on FCM yield, milk gross energy content, and composition of milk (%) in terms of milk fat, protein, lactose over the lactation length is shown in table 7. Compared to that of low feeding level, high level of feeding had no significant effect on FCM yield ($p=0.818$) and lactose content ($p=0.093$) but significantly reduced the milk fat ($p<0.001$), protein ($p<0.05$) and gross energy ($p<0.001$) content. However, in ruminants, provided rumen conditions are optimum, high intake is often associated with high production by increasing both energy and protein availability at the tissue level. Hadijpanayiotou and Morand-Fehr (1991) reported that high energy (125% of NRC, 1981) intake during last two months of pregnancy and continued in the lactation period had increased the milk yield of Damascus goat during 1st 8 weeks of lactation

Table 7. Effect of feeding level on daily FCM yield (g/d), fat, protein and lactose content (%) and milk gross energy excretion (MJ/kg) over the whole experimental period

Parameter	Feeding level				Significance
	High	SE	Low	SE	
FCM g/d	1,942	55.8	1,927	63.7	NS
Milk fat (%)	3.14	0.062	3.54	0.071	***
Milk protein (%)	2.94	0.036	3.04	0.041	*
Milk lactose (%)	4.55	0.016	4.52	0.018	NS
Milk net energy (MJ/kg)	2.65	0.031	2.82	0.036	***

*** $p<0.001$, NS=not significant.

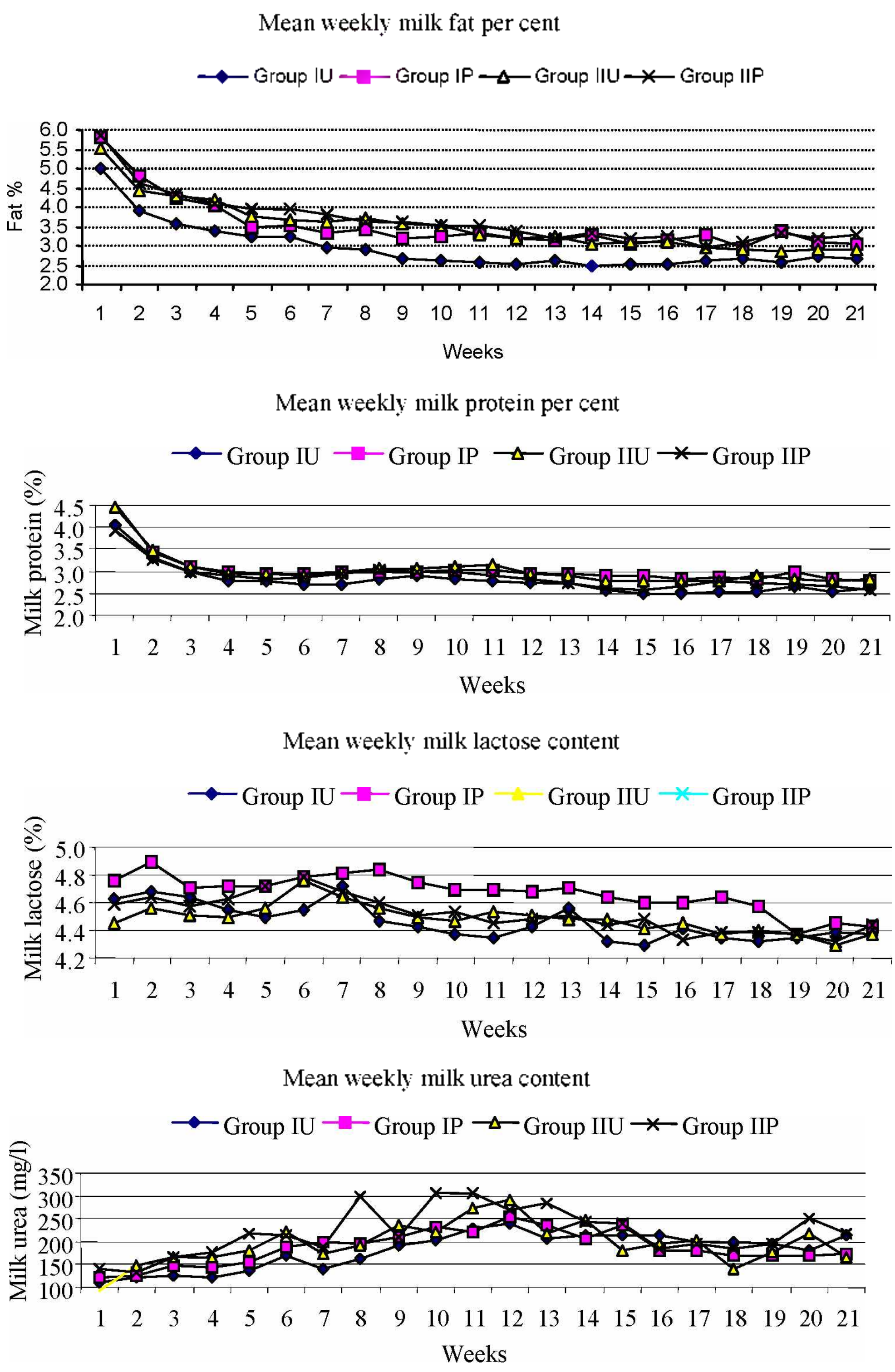

Figure 4. Weekly average milk, fat protein, lactose and urea content of different groups of animals during 21 weeks of lactation. Each value represents mean of at least 5×3=15 observations

compared to a 100% NRC (1981) allowance. However, similar response was not observed with Zairaibi breed (Gihad et al., 1986). Absence of response to higher feeding level in this trial could be due to inefficient rumen fermentation with consequent lower MP and ME yield relative to intake, or intake were well in excess of animal requirement. The ME intake at high and low level of feeding were 25.59 and 22.77 MJ/animal/d, excluding the

ME for maintenance of 9.79 and 9.87 MJ/animal/d, there should be 15.8 and 12.9 MJ ME/animal/d available for milk production. The FCM yield of 1.94 and 1.93 kg/animal/d for high and low feeding levels should have required 9.15 and 9.10 MJ ME/animal/d (assuming 4.714 MJ ME/kg FCM, Sauvant and Morand-Fehr, 1991), respectively. Thus, according to Sauvant and Morand-Fehr, (1991) estimate, ME supply in present trial at high and low level of feeding were 1.72 and 1.42 times higher respectively than the actual requirement.

Reduction of milk fat content by 13% with high level of feeding in this trial is comparable with 15-35% reduction (Morand-Fehr et al., 1991) in response to increase energy supply. Besides, dietary composition may also have played an important role here. The hay : pellet DM intake ratio were 0.31 and 0.51, respectively for high and low level of feeding. Higher hay intake at low feeding level must have resulted higher molar proportion of acetate (the main precursor for the fatty acid synthesized in the udder) production due to higher availability of structural carbohydrate with consequent higher milk fat content. Mowlem et al. (1985) showed that fat content of lactating goat reduced by 3.33% with the decrease in dietary hay: concentrate ratio from 2.06 to 0.48. Hof et al. (1994) pointed out that fat secretion is less dependent on energy supply because the extra energy intake stimulates the production of glucogenic nutrients in the rumen, which in turn stimulates lactose and protein synthesis (MacRae et al., 1988; Thomas and Martin, 1988). However, in this trial, milk protein also decreased ($p<0.05$) by 0.1 percentage point, but lactose remains unchanged with high level feeding, which ultimately resulted lower ($p<0.001$) net energy content of milk in that group. This is different from observation that higher energy supply increases milk protein by 0.1 to 0.15 percentage points in dairy goat (Morand-Fehr et al., 1991). This may indicate that in the present trial glucogenic nutrient (propionate and amino acids) yield was lower at high level of feeding probably due to inefficient fermentation.

Effect of protected protein on milk yield

Effect of dietary inclusion of formaldehyde treated (protected) or raw (unprotected) soya-meal on daily FCM yield (g/d), fat, protein and lactose content (%) and milk NE excretion (MJ/kg) over the whole experimental period is shown in table 8. Protected soya-meal significantly increased ($p<0.001$) the FCM yield, milk fat and milk GE content but had no effect on milk protein content.

The quantity and quality of protein available at the intestine may limit the milk yield (Hadijpanayiotou and Morand-Fehr, 1991). In the present trial, protected soya-meal significantly ($p<0.001$) increased MP availability at the tissue level (table 3), which might have resulted higher milk production in this group. However, dietary inclusion of formaldehyde treated soa-meal reported to have no effect on milk yield of dairy cow (Small and Gordon, 1985) and goat (Brun-Bellut et al., 1990). Hadijpanayiotou and Morand-Fehr (1991), however, showed a 9% (non-significant)

Table 8. Effect of dietary inclusion of formaldehyde treated (protected) or raw (unprotected) soya-meal on daily FCM yield (g/d), fat, protein and lactose content (%) and milk gross energy excretion (MJ/kg) over the whole experimental period

Parameter	Soya-meal				Significance
	Unprotected	SE	Protected	SE	
FCM g/d	1,703	54.1	2,166	66.6	***
Milk fat (%)	3.16	0.060	3.52	0.074	***
Milk protein (%)	2.97	0.035	3.00	0.043	NS
Milk lactose (%)	4.47	0.015	4.60	0.019	***
Milk net energy (MJ/kg)	2.65	0.030	2.82	0.037	***

*** $p<0.001$, NS=not significant.

Table 9. Effect of parity (1st or 3rd kidding) on daily FCM yield (g/d), fat, protein and lactose content (%) and milk gross energy excretion (MJ/kg) over the whole experimental period

Parameter	Parity				Significance
	1st	SE	3rd	SE	
FCM g/d	1,689	54.2	2,180	67.8	***
Milk fat (%)	3.45	0.060	3.22	0.076	**
Milk protein (%)	2.99	0.035	2.97	0.044	NS
Milk lactose (%)	4.63	0.015	4.43	0.019	***
Milk net energy (MJ/kg)	2.80	0.030	2.67	0.038	***

*** $p<0.001$, ** $p<0.01$, NS=not significant.

increase in FCM yield of Damascus goat with protected soya-meal. The response is much lower than that of the 27% increase in FCM yield in the present trial.

Quality and quantity of dietary protein reported to have no effect on overall milk composition of goat (Morand-Fehr et al., 1991), cattle (Remond, 1985) and sheep (Robinson et al., 1974). However, in this trial, this was observed only for protein component of milk but not for fat, lactose and NE content. Partial replacement of soya-meal with fish meal (protein source rich in rumen undegradable protein) improved the fat and protein percent of Damascus goat by 0.4 and 0.3 percentage unites, respectively without altering the milk output (Hadijpanayiotou et al., 1987). Comparable values in this trial were 0.356 and 0.041 percentage units for fat and protein respectively. Improvement due to protected protein supply in lactose and NE content of milk was 0.129 percentage units and 0.17 MJ/kg milk respectively, but there is no comparable data available to compare these values.

Effect of parity on milk yield

Effect of parity (1st or 3rd kidding) on daily FCM yield (g/d), fat, protein and lactose content (%) and milk NE excretion (MJ/kg) over the whole experimental period is shown in table 10. As expected, animals in 3rd parity yielded 490 g more ($p<0.001$) FCM daily than those of 1st parity. This result is coherent with the observation of Peris et al. (1996) and Ilahi et al. (1999) who showed that adult goats have higher production level than primiparous goats. Ilahi et al. (1999) suggested that this is due to interaction between milk secretion level and the development of mammary gland. Another factor could be that primiparous goats divert part of their available nutrient for attaining mature size.

Generally, there is an inverse correlation between milk out put and concentration (Morand-Fehr et al., 1991). However, in the present trial, milk fat (0.227 percentage units), lactose (0.186 percentage units) and NE (0.171 MJ/kg) content of milk were higher in animals of 3rd parity. Morand-Fehr et al. (1991) suggested that milk composition can be effected by many interdependent factors like breed, nutrition, milking, season of parturition, number of lactation and pathological condition.

Effect of energy-protein interaction on milk yield

Effect of dietary energy and protein concentration on average daily FCM yield (g/d), fat, protein, lactose (all in %), urea (mg/l) and NE (MJ/kg) content of milk over the whole experimental period is shown in table 11. Except milk urea, all milk parameters were significantly ($p<0.001$) affected by the level of dietary energy and protein. Average FCM yield was the lowest (also see figure 4) at low level of feeding with unprotected soya-meal (1,600 g/d) and the highest also at low feeding level with protected soya-meal (2,254 g/d) and yield was intermediate at groups with high level of feeding, but protected group yielded daily 272 g more milk ($p<0.001$) than the unprotected group. In dairy cow, higher energy intake reported to be responded by higher daily milk production (Hof et al., 1994; Oldham and Emmans, 1988) by stimulating lactose synthesis from propionate (Oldham and Emmans, 1988) and by availability of amino acids for protein synthesis (Seal and Parker, 1991). Similarly, increased post ruminal availability of digestible protein or amino acids stimulate milk and milk protein production in dairy cows (Schwab et al., 1976; Clark et al., 1977; Ørskov et al., 1977; Rodgers et al., 1984; Whitelaw et al., 1986). However, protein : energy ratio (g MP/MJ ME) in the estimated absorbed nutrients appears to be the determinant factor for the FCM yield in this trial. Figure 5 (here, data from two animals were excluded as they were not in normal distribution within 95% confidence interval) shows the linear increase in FCM yield with MP relative to ME intake. For each gram increase in MP relative to ME intake, the FCM increased by 1418±275.6 g ($r^2=0.58$; $p<0.001$). Here, the diminishing return effect with increasing protein intake (MacRae et al., 1988; Subnel et al., 1994) will determine the break point of linearity, which in turn will probably be determined by the genetic limit of the animal and amino acid composition of the available protein (Hof et al., 1994). In dairy cow, it was suggested that when MP supply exceeds 16 g/MJ ME then extra MP results in only a marginal increase in milk protein out put (Hof et al., 1994). On a normal diet, MP: ME ratio does not change very much due to fermentative digestion in the rumen (ARC.

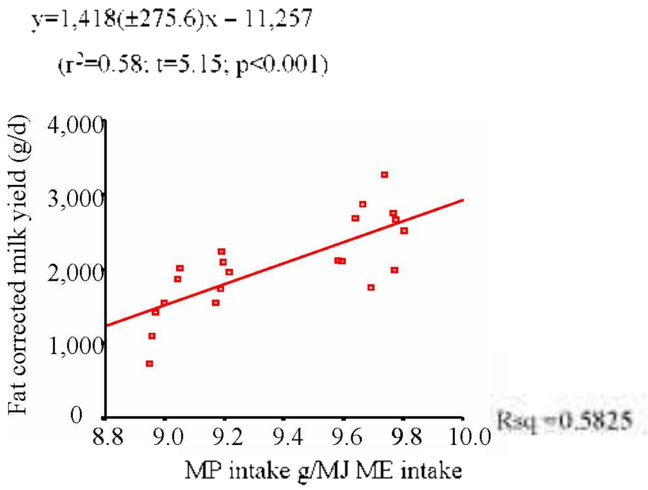

Figure 5. Relationship between fat corrected milk yield (FCM) and metabolizable protein (MP) availability relative to ME intake. Each point represents mean FCM yield of 147 repeated measurements on an individual animal over the 21 weeks of experimental period

Table 10. Effect of dietary energy and protein concentration on daily FCM yield (g/d), fat, protein, lactose (all in %), urea (mg/l), NE (MJ/kg) content of milk, live weight gain (g/d) over the whole experimental period

Parameter	Treatment combinations[1]								Significance
	IU	SE	IP	SE	IIU	SE	IIP	SE	
FCM g/d	1,806[a]	73.0	2,078[b]	70.9	1,600[d]	67.0	2,254[a]	91.1	**
Milk fat (%)	2.84[c]	0.081	3.43[b]	0.079	3.48[b]	0.075	3.60[a]	0.102	**
Milk protein (%)	2.82[c]	0.047	3.05[a]	0.046	3.12[a]	0.043	2.96[b]	0.059	***
Milk lactose (%)	4.45[d]	0.021	4.65[a]	0.020	4.49[c]	0.019	4.54[b]	0.026	***
Milk urea (mg/l)	175	6.9	183	6.7	192	6.4	204	8.7	NS
Milk NE (MJ/kg)	2.49[b]	0.041	2.81[a]	0.040	2.81[a]	0.038	2.83[a]	0.051	***
FCM g/MJ ME intake	68	2.98	92	2.89	76	2.73	95	3.71	NS
FCM g/g MP intake	7.48	0.322	9.42	0.312	8.45	0.295	9.91	0.401	NS
Efficiency of ME utilization for milk (MJ/MJ ME intake)#	0.39[b]	0.008	0.45[a]	0.008	0.43[a]	0.008	0.46[a]	0.010	*
Efficiency of MP utilization for milk (g/g MP intake)#	0.35	0.006	0.37	0.005	0.36	0.005	0.37	0.007	NS
Live weight gain (g/d)	41	15.98	6	15.16	17	13.37	19	15.98	NS
Plasma glucose (mmol/l)	3.19	0.078	3.12	0.080	3.09	0.072	3.04	0.098	NS
Plasma urea (mmol/l)	3.73	0.300	3.55	0.317	4.25	0.283	4.05	0.383	NS

[a,b,c,d] Values with different superscripts in the same row differ significantly; * $p<0.05$, ** $p<0.01$, *** $p<0.001$; NS=not significant.
Estimated as (ME or MP in milk)/(ME or MP in milk + available ME or MP for production).
[1] IU=High feeding level with unprotected soya-meal; IP=High feeding level with uprotected soya-meal; IIU=Low feeding level with unprotected soya-meal; IIP=Low feeding level with protected soya-meal.

Table 11. Effect of parity (1st or 3rd) on nutrient partitioning of goat over the 21 weeks of the experimental period

Parameter	Parity				Significance
	1st	SE	3rd	SE	
Live weight (kg)	46.13	1.424	58.08	1.592	***
Live weight gain (g/d)	41.1	10.11	0.3	11.30	*
FCM yield (g/d)	1,862	168.1	2,395	187.9	*
ME intake (MJ/d)	22.92	0.912	25.45	1.020	p=0.085
MP intake (g/d)	215	8.83	240	9.88	p=0.083
ME for maintenance (MJ/d)	8.98	0.202	10.68	0.226	***
MP for maintenance (g/d)	38.72	0.873	46.04	0.975	***
ME for milk (MJ/d)	9.44	0.849	12.50	0.921	*
MP for milk (g/d)	81.73	6.459	111.96	7.221	**
ME for weight gain (kJ/d)	1,370	376	27	420	*
MP for weight gain (g/d)	8.72	3.252	0.012	2.300	*

*** $p<0.001$, ** $p<0.01$,* $p<0.05$.

1984). High MP relative to ME intake can only be attained by supplying UDP in the diet, which in turn can increase protein and lactose synthesis and thus increase milk yield despite relatively lower dietary energy level. This is probably the reason why FCM yield in protected protein groups (IP & IIP) was higher when expressed either in g/MJ ME intake (92 & 95 vs. 68 &76) or as g/g MP intake (9.42 & 9.91 vs. 7.42 & 8.45) compared to that of the unprotected groups (IU & IIU).

Milk urea concentrations were 175, 183, 192 and 204 mg/l for group IU, IP, IIU and IIP respectively. Brun-Bellut et al. (1991) suggested that if milk urea is above 300 mg/l then there is an excess of RDP or an insufficiency of dietary energy and if milk urea is below 300 mg/l, this indicate either an insufficiency of RDP or of digested protein. On the other hand, Bellof and Weppert (1996) suggested that milk urea level below 180 mg/l and milk protein below 2.8% indicate low dietary RDP supply. In fact, estimated RDP supplies of 6.97(±0.025), 6.70(±0.024), 7.30(±0.023) and 6.83(±0.032) g/MJ ME intake were 0.89, 0.86, 0.93 and 0.87 of ARC (1984) recommendation (7.81 g RDP/MJ ME) for group IU, IP, IIU and IIP respectively. Apparently,

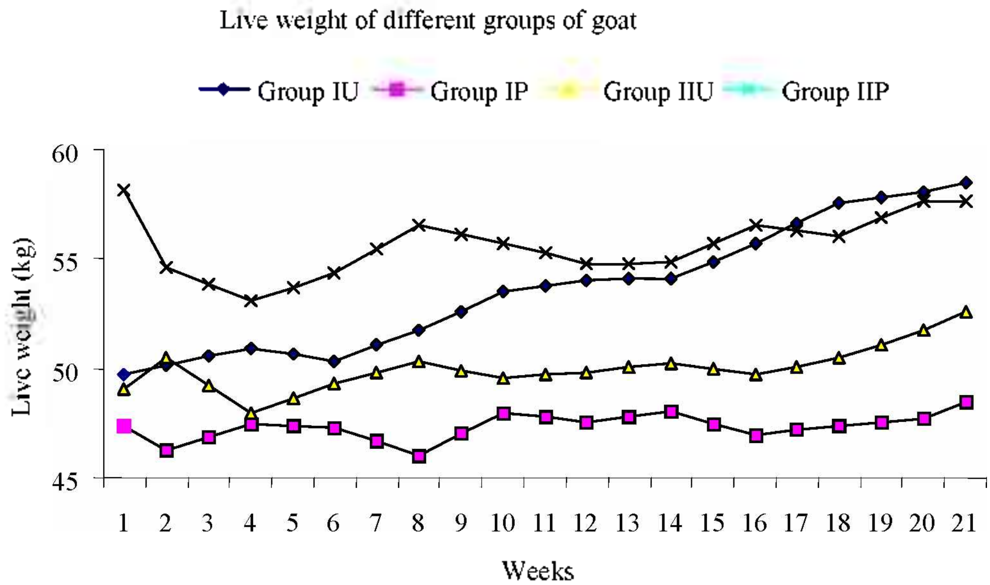

Figure 6. Average daily live weight gain of different groups of animals during 21 weeks of lactation.

these diets were adequate in fermentable energy (average, 11.38±0.081 MJ/kg DM, see table 1) but there was a true RDP deficiency in all these diets and the extent was more severe at high feeding level (6.84±0.019 mean±SE of group IU & IP), which must have reduced the efficiency of microbial protein yield (ARC, 1984) in these animals. Theoretically, animals in group IP (high feeding level with protected soya-meal) should have had the highest production (milk and/or live weight gain) response but they were next to group IIP (low feeding with protected soya-meal). In fact, these animals had the lowest RDP in their diet (6.7 g/MJ ME) which must have resulted low rumen-NH_3 concentration. At low rumen NH_3 concentration, assimilation of NH_3 to amino acids requires an additional ATP associated with two-step enzymatic process (glutamine synthetase and glutamate synthetase) of transferring the amide-N of glutamine to 2-oxalogutarate (Preston and Leng, 1987). This reduces the yield of Y_{ATP} (microbial protein g/mole of ATP used) yield from rumen fermentation of these animals (Preston and Leng, 1987, Clark et al., 1992). Thus, absence of production response at high level of feeding is probably due to lower MP yield relative to ME intake.

The efficiencies of utilization on ME for milk production were 0.39, 0.45, 0.43 and 0.46 and the efficiency of utilization of MP for milk production were 0.35, 0.37, 0.36 and 0.37, respectively for group IU, IP, IIU and IIP. These values are much lower than the AFRC (1998) values of 0.63 and 0.68, respectively for ME and MP utilization. One probable reason could be that the availability of ME and MP were overestimated. This is possible because factors which were used for these estimates are based on nutritionally balanced diet, whereas, diets in the present trial were deficient at least in RDP. However, efficiency of ME utilization for milk production is still higher ($p<0.05$) with protected soya-meal groups or groups with high MP relative to ME intake. This means that conclusion drawn in foregoing section that milk yield is dependent on MP availability relative to ME intake, is still valid.

Live weight change

Weekly live weight change of animals in different groups is shown in figure 6 and average live weight gain across the lactation is presented in table 11. Although not significant due to intra-group variation, animals at high feeding level with unprotected soya-meal gained at the rate of 41 g/d compared to 19 g/d in animals at low feeding level with protected soya-meal. Shajalal et al. (1992) showed higher growth rate (91 vs. 80 g/d) of young (11 months old) British Angora goats fed high energy-low protein (11.9 MJ ME and 108 g CP/kg) diet compared to that of low energy-high protein (10.2 MJ ME and 180 CP/kg) diet. Although animals were not slaughtered in the present trial, higher growth rate in group IU could be due to lower MP: ME ratio of absorbed nutrient, which partitioned more nutrients towards adipose tissue synthesis than to milk production. Similar phenomenon was observed in growing lambs where low dietary protein : energy ratio stimulated higher body fat and lower body protein deposition (Andrew and Ørskov, 1970). However, in the present trial, the result is confounded by the fact that each group contains animals both from 1st (high growth potentiality) and 3rd (low growth potentiality) parity. Animals in 3rd parity have almost attained their matured weight (58±1.59 kg), thus their nutrient partitioning expected to be different from that of animals in 1st parity (46±1.42 kg), which is shown in table 11. As stated earlier, animals in 3rd parity yielded 490 g more FCM daily than the animals in 1st parity but the later gained 41 g live weight daily compared to almost no gain in 3rd parity. It can be estimated from table 11 that, animals in 3rd parity utilized 0.42 and 0.19 proportion of their available ME and MP respectively for maintenance which are nearly similar to that of the 1st parity animals of 0.39 and 0.18, respectively. However, compared to that of the 1st parity, 3rd parity animals diverted more available ME (0.49 vs. 0.41) and MP (0.47 vs. 0.38) for milk production. Opposite was true for the live weight gain, where 1st parity animals used 0.06 and 0.04 respectively of available ME and MP for gain compared to almost nothing by the 3rd parity animals. Two points are apparent here :

i) Only small proportion (0.04-0.06) of available nutrients are being diverted for live weight gain. This is probably due to the genetic makeup of the German Fawn goat which is predominantly a dairy type goat.

ii) In this estimates, large proportion of estimated available nutrients remain unaccounted and it is more pronounced for the MP (0.34-0.40) than the ME (0.09-0.14) fraction. This further indicates an overestimation of MP availability, which is probably due to inefficient ruminal microbial protein production resulting from inadequate RDP supply. Probably, the extent of overestimation indicates the extent of inefficiency of these diets in converting food into utilizable nutrients compared to that of the AFRC (1998).

Plasma metabolites

Plasma glucose and urea concentrations were not significantly affected by different dietary combinations (table 10). However, plasma glucose concentrations in this trial (ranged between 2.84-3.35 mmol/l) fall in the lower limit of the normal range 2.22-4.17 mmol/l for goat (Ingolab, 2000). Hypoglycemic condition during lactation can be expected due to drainage of glucose for lactose synthesis (Subnel et al., 1994). However, none of the animals showed any symptom of ketosis. There was no apparent relationship between the plasma glucose and the milk yield or milk composition. Plasma urea derives from the rumen ammonia or from de-amination of amino acids during protein turnover and gluconeogenesis. In the present trail plasma urea concentration ranges between 2.93 to 4.81 mmol/l that also falls on the lower limit of normal range of 2.00-7.17 mmol/l (Ingolab, 2000). Plasma urea was non-significantly (p=0.066) higher at low level of feeding (4.15 mmol/l) than at high level of feeding (3.63 mmol/l). This is probably due to the fact that low level of feeding results high rumen pH, which allows NH_3 to remain in non-ionised form and, hence, allows to be absorbed across the rumen wall and convert into urea (Blauwiekel and Kincaid, 1984). There was no apparent relationship between the plasma urea and the milk yield or milk composition.

CONCLUSION

Although this experiment was conducted to determine the effective level of dietary energy and also to determine the effect of protected protein inclusion on lactation performance of German Fawn goat, the result is far from conclusive. Energy effect could not be depicted due to inadequate RDP content of the diet, which resulted inefficient rumen fermentation with reduced efficiency of nutrient utilization. However, protected protein seems to improve production possibly by improving protein : energy ratio of the absorbed nutrient. In assessing the impact of dietary energy and protected protein, similar trial with higher number of animals and adequate rumen RDP is needed to be tested.

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