WORLD RABBIT SCIENCE 1998, vol. 6 (3-4), 271-276.

EFFECT OF DIETARY ENERGY AND PROTEIN LEVEL ON PERFORMANCE AND DIGESTIBILITY PARAMETERS IN PREGNANT AND IN LACTATING RABBIT DOES UNDER TROPICAL ENVIRONMENT

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ABSTRACT: The study was conducted on pregnant and lactating does to assess reproductive performance and digestibility of nutrients on nine groups of six does each maintained on three levels of energy (2400, 2700 and 2900 kcal DE/kg DM) and protein (15, 18 and 20%) in nine combinations. The does were maintained on similar diets during both the phases. During gestation average temperature at 14:30 was 31.4°C, and 40.7°C during the lactation period. Dry matter intake of the does was only 17% higher in lactation than during gestation. Digestibility of DM, CP and energy was influenced by energy and protein concentrations of the diets both in gestation and lactation phases. ADF digestibility was not influenced (19.6% on average). During gestation phase (22nd to 28th day) does were in positive nitrogen balance (1.58 - 2.53 g/d) with a body weight gain (from mating to parturition) of 0.35 - 0.44 kg, while lactating does lost weight ranging from 0.10 - 0.17 kg. The litter weight at birth was similar in does fed on diets containing variable levels of energy and protein during gestation phase (346 to 396 g) whereas litter weight at weaning (28 days) was influenced both by energy and protein levels of the diets. It was higher (P<0.01) on medium and high compared to low level of energy and protein. These results suggest that a diet containing 18% CP and 2700 kcal DE/kg of feed is optimum for reproductive rabbit does under tropical environment.

RESUME : Effets des teneurs en énergie et en protéines de l'alimentation sur les performances de reproduction et la digestibilité de l'aliment, chez des lapines gestantes puis allaitantes élevées en milieu tropical.
L'étude a été conduite avec des lapines gestantes puis allaitantes réparties en 9 lots équivalents de six individus. Les performances de reproduction et la digestibilité des aliments ont été étudiées pour chacune des 9 combinaisons factorielles correspondant à 3 teneurs en énergie de l'aliment (2400 - 2700 et 2900 kcal/kg MS) et 3 teneurs en protéines (15 - 18 et 20% /MS). Pendant la période de gestation la température moyenne à 14h30 a été de 31,4°C, et de 40,7°C pendant la période d'étude de la lactation. L'ingestion de matière sèche a été de 17% plus élevée pendant la lactation par rapport à la période de gestation. La digestibilité de la matière sèche, des protéines ou de l'énergie des aliments a été influencée par la teneur en protéines ou en énergie aussi bien en gestation qu'en lactation. Celle des fibres (ADF) n'a été modifiée par aucun des paramètres étudiés (19,6% en moyenne). Au cours de la gestation, les lapines ont été en bilan azoté positif (1,58 à 2,53 g N /jour entre le 22e et le 28e jours) et leur poids vif apparent a augmenté de 0,35 à 0,44 kg entre la saillie et le 28ème jour de gestation. A l'inverse, les lapines ont perdu 0,10 à 0,17 kg entre la mise bas et le sevrage (28 j.), sans relation avec le régime alimentaire utilisé. Le poids et l'effectif des portées ont été similaires pour tous les régimes alimentaires (346 à 396 g - 7,1 lapereaux en moyenne). Par contre, le poids de portée au sevrage est plus élevé (P<0,01) avec les aliments ayant une teneur moyenne ou forte en énergie ou en protéines. Dans leur conclusion, les auteurs suggèrent qu'un aliment contenant 18% de protéines et 2700 kcal par rapport à la matière sèche, est le mieux adapté aux conditions tropicales de production.

INTRODUCTION

The productive and reproductive performance of an animal is governed by its genetic potential, the composition of feed consumed and the environment. Considering genetic and prevailing environmental conditions as less modifiable, it is the feed which can easily be modified to increase level of production and reproduction. Generally the aim of developing feeding practices is to meet nutrient requirement for production and reproduction without significantly altering the body composition over the breeding cycles. A number of experiments have been conducted (PARTRIDGE and ALLAN, 1982; PARTRIDGE *et al.*, 1986; LEBAS, 1989; XICCATO *et al.*., 1992) in temperate location with the objective to assess productive and reproductive performance, efficiencies of nutrient utilisation and requirement of does on different type of diets. Unlike developed countries, the rabbit feeding experiments in developing countries are planned to formulate a all purpose diet suited both for growing rabbit and does in different physiological stages whereas the published reports on this aspect are few. Therefore present experiment was conducted on pregnant and lactating does maintained on three levels each of energy and protein to assess their productive and reproductive performances.

MATERIALS AND METHODS

Fifty four does (2 to 2 1/2 year old) of Soviet Chinchilla and White Giant breeds were randomly assigned to nine equal groups and maintained in individual cages (45 cm x 50 cm x 37 cm) made up of wire mesh supported with welded angle iron frame having provision of feeder and watering bowl. The experiment was started in early March and terminated by 3rd week of May. The range of the ambient temperature and relative humidity (RH) of the location during the experiments are presented in Table 1. Does were assigned to experimental feeding after mating. Pregnancy diagnosis was carried out by palpation method on 14th day after mating and does found empty were re-bred. They were offered *ad libitum* pelleted feed once daily during one month of gestation period and refusal of previous day if any, was weighed and

Table 1 : Ambient temperature (AT) and relative humidity (RH %) of the location during experimental period, at 7:30 and 14:30 h

	AT °C	RH %	Min Temp. °C	Max. Temp. °C
Gestation phase				
07:30 h	18.7 (10.3 - 27.5)	47.6 (17.0 - 84.0)	17.2 (10.3 - 24.0)	31.0 (23.2 - 36.2)
14:30 h	31.4 (20.0 - 37.0)	18.1 (5.0 - 57.0)	17.2 (10.3 - 24.0)	31.3 (24.0 - 36.8)
Lactation phase				
7:30 h	29.5 (22.3 - 34.5)	36.4 (18.0 - 82.0)	26.5 (20.5 - 32.0)	40.4 (31.7 - 44.2)
14:30 h	40.7 (32.0 - 44.5)	16.6 (8.5 - 44.0)	25.8 (20.5 - 32.0)	41.5 (31.7 - 44.5)

The values in parenthesis are the range of the means observed during experimental period.

discarded before offering fresh feed. Animals had free access to clean drinking water in individual bowls fixed in the cages.

The pregnant does were transferred to the kindling cages attached with nest box two days before expected date of kindling. On the day of kindling, doe weight, litter size and litter weight was recorded. The feed and feeding schedule was the same as in pregnancy phase. Does were maintained in kindling cages during 28 days of lactation phase. To avoid trampling of kits by does the kits were allowed to suckle the doe once daily for 15 minutes in the morning hours by opening sliding window between kindling cage and nest box. The does were not re-bred till weaning of the kits. Two weeks after kindling the window between kindling cage and nest box was kept open all the time and kits were allowed free movement between nest box and kindling cage, except during 5 days faecal collection period when kits were not allowed to enter the does enclosure to avoid contamination of does faeces with that of kits, while the does were allowed to enter nestling box for 15 minutes to suckle the kits. There was no case of abortion or death of any doe during the trial period.

Feed intake was determined daily and the does were weighed weekly throughout the experimental period. Litter size and litter weight were recorded at birth and weekly from birth to weaning (4 weeks). Two metabolism trials of five days duration were performed on all the does, at 22 to 28 days of gestation and 15 to 20 days of lactation by attaching collection funnels under the cage having facility for quantitative collection of faeces and urine. The milk yield of the does was calculated from kit weight considering 0.56 kg gain in kit weight for each kg of milk consumed (PARTRIDGE an ALLAN, 1982). The milk consumed by the dead kits during birth to weaning was accounted for and the required corrections were made in arriving at milk consumption by the kits.

Complete pelleted diets were prepared with three levels each (low, L ; medium, M ; high, H) of protein P

Table 2 : Ingredients and chemical composition of diets.

Ingredients %	LELP	LEMP	LEHP	MELP	MEMP	MEHP	HELP	HEMP	HEHP
Ingredients composition (%)									
Barley	20	13	6	40	33	26	64	53	41
Groundnut cake	10	24	38	10	24	38	8	19	31
Wheat bran	20	13	6	20	13	6	5	5	5
Cowpea hay	35	35	35	15	15	15	5	5	5
Fish meal	5	5	5	5	5	5	8	8	8
Molasses	8	8	8	8	8	8	8	8	8
Mineral Mixture	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Chemical composition (% DM)									
Dry matter	92.50	93.70	93.20	92.00	92.20	93.00	93.90	93.50	93.00
Crude protein	14.64	18.32	20.08	15.76	18.69	20.15	15.22	18.69	19.74
ADF	26.20	25.10	26.30	18.75	17.92	17.95	15.41	14.92	15.21
DCP, gestation	8.68	12.32	14.41	11.96	13.52	15.30	11.10	14.35	15.16
DCP, lactation	10.42	13.04	14.94	12.36	14.09	15.71	11.80	15.41	15.48
GE (kcal/kg)	3450	3820	3940	3640	3820	3910	3750	3850	3900
DE (kcal/kg) gest.	2232	2487	2478	2655	2729	2794	2903	2858	2912
DE (kcal/kg) lact.	2478	2512	2441	2696	2649	2758	2984	2939	2874

Table 3 : Feed intake and nutrient utilisation by the does in gestation phase.

Parameters	Energy				Protein				SEM
	LE	ME	HE	R	LP	MP	HP	R	
DMI (g/d)	113.9	115.6	109.7	0.124	109.8	115.1	114.3	0.117	6.3
DMI (g/kg $W^{0.75}$)	43.1	44.9	42.1	0.155	42.8	44.8	42.6	0.131	2.4
Digestibility coefficients (%)									
- DM	64.65^a	72.20^b	77.00^b	0.726	74.47^B	69.37^A	70.02^A	0.524	1.27
- CP	65.87^a	74.76^b	75.52^b	0.689	69.39^a	71.91^{ab}	74.85^b	0.551	1.06
- ADF	18.81	19.62	19.58	0.235	19.43	19.64	18.94	0.187	0.49
- Energy	64.24^a	71.95^b	75.53^b	0.851	71.69	70.27	69.76	0.147	0.90
N intake (g/d)	3.22	3.13	2.92	0.137	2.46^a	3.17^{ab}	3.65^b	0.560	0.23
N voided in faeces (g/d)	0.91^b	0.69^a	0.70^a	0.751	0.68	0.86	0.76	0.256	0.06
N voided in urine (g/d)	0.27	0.29	0.28	0.045	0.20	0.28	0.36	0.393	0.04
N balance (g/d)	2.04	2.15	1.95	0.166	1.58^a	2.03ab	2.53^b	0.570	0.18
N retention (% of intake)	62.06	67.36	65.49	0.220	63.79	61.94	69.19	0.308	2.38
DCP intake (g/kg $W^{0.75}$)	5.07	6.10	5.68	0.333	4.53^a	5.97^b	6.35^b	0.620	0.30
DE intake (kcal/kg $W^{0.75}$)	103.5^a	122.5^b	121.8^b	0.604	111.4	120.5	115.9	0.170	6.45
Doe weight at mating (kg)	3.24	3.23	3.21	0.031	3.19	3.15	3.35	0.246	0.088
Doe weight at 4th week (kg)	3.65	3.66	3.59	0.077	3.54	3.59	3.77	0.277	0.090
Wt gain during pregnancy (kg)	0.41	0.43	0.38	0.126	0.35	0.44	0.42	0.254	0.031

Values bearing unlike superscripts in sub rows differ significantly (capital letters : $P<0.05$; small letters : $P<0.01$)

(15, 18 and 20%) and energy E (2400, 2700 and 2900 kcal DE/kg) in nine combinations. The diets were designated as LELP, LEMP, LEHP, MELP, MEMP, MEHP, HELP, HEMP and HEHP. Ingredient and chemical composition of the diets are presented in Table 2. Feed pellets were prepared using ground ingredients mixed with 8 kg molasses dissolved in 40 litres of water/quintal of feed. Prepared feed mix was passed through 4 mm die cast in a laboratory model pelleting machine and the extruded pellets were sun dried and stored in gunny bags for use in the feeding experiment.

Pooled representative samples of feed offered, faeces and urine voided from five days collection period were later analysed for chemical composition (AOAC, 1984) and calculation of digestibility coefficients. Feed and nutrient intake, digestibility coefficients, body weight changes and litter weight were subjected to analysis of variance considering energy and protein levels as two factors with two ways interactions in 3 x 3 factorial design (GOMEZ and GOMEZ, 1976). Significant group differences were compared using Duncan's Multiple Range Test (DUNCAN, 1955). Statistical analysis indicated non significant interactions in energy and protein levels for most of the parameters hence the data were presented only on the basis of main effects i.e. energy and protein variations. The two breeds employed have been raised under the prevailing hot semi-arid environment since decades and their production performances during this period were found similar. Hence, the breed group difference was not considered as a variable in statistical analysis.

RESULTS AND DISCUSSION

Gestation

Dry matter intake was similar in the experimental does fed on varying level of energy and protein averaging to 113.07 g/d or 43.38 g/kg $w^{0.75}$ Digestibility of dry matter was higher ($P<0.01$) in medium and high energy than low energy regimen (Table 3). Digestibility of crude protein was lower ($P<0.01$) in LE and LP than in other groups. Digestibility of energy was higher in medium and high energy regimens whereas, it was not influenced by dietary protein content. The increase in digestibility of DM, CP and energy from low to medium and high energy regimen could be due to lower roughage content of high energy diets. It is also established that digestive efficiency increase to a greater extent by increasing energy content of diet (PARTRIDGE and ALLAN, 1982; WISEMAN *et al.*, 1992; PRASAD *et al.*, 1996). Higher digestibility of CP in ME and HE compared to LE diets could also be due to associative effect and longer retention time of feed in gut (DE BLAS *et al.*, 1986).The increase in CP digestibility from LP to HP was however due to incorporation of higher amount of protein supplement in these diets which increased the protein digestibility (MAERTENS and DE GROOTE, 1984)

Nitrogen intake, its excretion in urine and N balance, were similar in LE, ME and HE diets whereas N voided in faeces was higher in low energy compared to medium and high energy diets. The higher out go of faecal N on LE regimen was due to higher roughage content of the diets. Nitrogen intake and its balance was higher ($P<0.01$) in MP

Table 4 : Feed intake and nutrient utilisation by the does in lactation phase

Parameters	Energy				Protein				SEM
	LE	ME	HE	R	LP	MP	HP	R	
DMI (g/d)	124.28	143.47	130.06	0.274	112.29^{a}	151.65^{b}	133.87^{ab}	0.549	6.553
DMI (g/kg $W^{0.75}$)	53.01	61.68	54.12	0.313	48.84^{a}	65.48^{b}	54.50^{ab}	0.561	2.846
Digestibility coefficients (%)									
- DM	65.84^{a}	72.24^{b}	76.19^{b}	0.698	75.38^{b}	70.02^{a}	68.87^{a}	0.667	1.009
- CP	72.49^{a}	77.45^{b}	80.16^{b}	0.683	75.90	76.55	77.65	0.155	0.944
- ADF	19.53	19.83	20.57	0.175	19.56	19.98	20.39	0.135	0.825
Energy	66.54^{a}	71.31^{b}	75.68^{c}	0.651	75.15^{b}	69.64^{a}	68.74^{a}	0.493	0.994
N intake (g/d)	3.53^{A}	4.18^{B}	4.22^{B}	0.655	2.73^{a}	4.93^{b}	4.27^{b}	0.752	0.203
N voided in faeces (g/d)	0.96^{B}	0.94^{B}	0.78^{A}	0.598	0.65^{a}	1.10^{b}	0.94^{b}	0.699	0.054
N voided in urine (g/d)	0.45^{b}	0.27^{a}	0.26^{a}	0.621	0.28	0.31	0.38	0.269	0.027
N balance (g/d) *	2.12^{a}	2.97^{b}	3.18^{b}	0.531	1.80^{a}	3.52^{b}	2.95^{b}	0.684	0.158
DCP intake (g/kg $W^{0.75}$)	6.82^{a}	8.64^{b}	7.84^{ab}	0.648	5.65^{a}	9.28^{b}	8.37^{b}	0.526	0.373
DE intake (kcal/kg $W^{0.75}$)	131.48^{a}	166.25^{b}	158.47^{ab}	0.536	132.32^{a}	176.88^{b}	147.00^{a}	0.542	7.516
Doe wt. at kindling (kg)	3.27	3.30	3.25	0.223	3.17	3.27	3.38 (6)	0.105	0.073
Doe wt. at 4th week lact. (kg)	3.11	3.13	3.15	0.054	3.04	3.11	3.23 (6)	0.310	0.072
Wt. change during lact. (kg)	-0.16	- 0.17	- 0.10	0.167	- 0.13	- 0.16	- 0.15 (6)	(6) 0.067	0.048

Values bearing unlike superscripts in sub rows differ significantly (capital letters : $P<0.05$; small letters : $P<0.01$) ; * ingestion minus faecal and urine output.

and HP compared to LP diet (Table 3) due to increased dietary protein content in medium and high protein regimen. Digestible crude protein (DCP) intake per day was similar in LE, ME and HE diets whereas it increased from low to medium and high protein regimen. Digestible energy (DE) intake was influenced by energy content of diet and was higher (P<0.01) on medium and high as compared to low energy regimen. The DE intake in LP, MP and HP groups was however found to be similar. Voluntary feed intake was also similar in LE, ME and HE groups. Although it is established that dry matter intake (DMI) and energy concentration of the diet within limits are inversely related, the same was not reflected in this study. Since the feed intake was similar on all the diets, the DE intake increased on ME and HE compared to LE diets.

All the does gained weight during pregnancy (0.35 to 0.44 kg) with no effect of dietary energy or protein levels. The recorded gain in weight was due to foetal growth as evident by almost similar body weight of does at mating and kindling. PARIGI BINI *et al.* (1991) reported that in primiparous does during the gestation period (0 to 21 days) increase in live weight was similar to that of non pregnant does which was independent of dietary variations. Whereas in present experiment the does were in their 4th pregnancy cycle hence there was insignificant increase in their actual live weight during pregnancy.

The dietary energy and protein levels had non-significant influence on litter weight and litter size at birth averaging to 376 g and 7.1 kits, respectively (Table 5). The present finding that litter size is not influenced by dietary variation in pregnancy phase is in agreement with earlier findings (PARTRIDGE *et al.*, 1986; LEBAS, 1975; PARTRIDGE and ALLAN, 1982). Contrasting reports are available on the effect of pregnancy diet on kits birth weight. PARTRIDGE *et al.* (1986) has reported significantly higher litter weight at birth on high energy diets while PARTRIDGE and ALLAN (1982) did not observe significant effect of protein levels on kits birth weight. In present study the effect of energy and protein levels on birth weight is not very clear. On the opposite, mortality of kits during lactation period was higher in LE and LP compared to other feeding regimens, which could be due to lower milk yield of does in these feeding regimens (Table 5).

Lactation

Dry matter intake of does increased by 17% from gestation to lactation phase to support higher nutrient drain from body. The increase of DMI in lactation compared to that of gestation phase was of lower magnitude then the reported values of 80-90% in the literature (LEBAS *et al.*, 1984). The observed lesser increase was probably due to prevailing higher ambient temperature during the lactation period (Table 1) resulting in discomfort and low feed intake by the does (STEPHEN, 1980). Energy level of diets did not influence the DMI of the does whereas DMI was significantly (P<0.01) higher in medium protein followed by high and low protein regimen (Table 4).

Digestibility of DM, CP and energy was significantly (P<0.01) lower in low energy compared to medium and high energy regimen which was due to lower content of roughage in ME and HE diets. In general the digestibility of CP increased in lactation compared to gestation phase probably due to decrease in

Table 5 : Litter weight and litter size on different diets.

	Energy				Protein				SEM
	LE	ME	HE	R	LP	MP	HP	R	
Litter weight at birth (g)	396	383	350	0.215	346	390	393	0.232	23
Litter size at birth	7.7	7.3	6.4	0.240	7.0	7.3	7.1	0.269	0.85
Litter weight at weaning (g)	1572[a]	1821[b]	1717[b]	0.652	1467[a]	1805[b]	1838[b]	0.721	86
Litter size at weaning	4.8	5.8	4.7	0.243	4.3	5.6	5.3	0.297	0.90
Kits dead during lactation	2.9[B]	1.5[A]	1.7[A]	0.626	2.7[B]	1.7[A]	1.8[A]	0.610	0.82
Litter weight gain (g)									
- from birth to weaning	1176[a]	1438[b]	1367[b]	0.621	1121[a]	1415[b]	1445[b]	0.598	56
- corrected for kit mortality during the period	1458	1630	1556	---	1398	1658	1617	---	---
Milk yield up to weaning ** (g)	2603	2910	2778	---	2496	2960	2885	---	---
Milk yield g/d	92.9	103.9	99.2	---	89.1	105.7	103.0	---	---

Values bearing unlike superscripts in sub rows differ significantly (capital letters : $P<0.05$; small letters : $P<0.01$)
** Calculated milk yield on litter weight gain corrected for kit mortality during the period, considering that 1 kg milk consumed by kits will provide 0.56 kg gain (PARTRIDGE and ALLAN, 1982)

endogenous faecal nitrogen, therefore increase in apparent CP digestibility. Nitrogen intake was higher in medium and high energy and protein regimen (Table 4) which was due to higher feed intake on these diets. Assessment of N balance accounting faecal and urinary loss was positive in all the groups. The actual N balance accounting the N loss in milk was not studied. However, considering the average milk yield of these does to be 99 ml, apparently 2.2 g N (Rabbit milk contains 14% protein with 16% N) was drained from the body in milk. Hence the apparent N balance although positive accounting faecal and urinary losses, was probably negative accounting N losses in milk in some groups. This negative N balance was reflected in body weight loss of does during lactation.

DCP intake was higher ($P<0.01$) in medium energy followed by high and low energy regimen in decreasing order, whereas DCP intake was similar in medium and high protein and lower on low protein diets. Similarly DE intake per kg metabolic body weight was higher in ME, MP followed by HE, HP, LE and LP regimen in decreasing order, which is possibly a reflection of corresponding higher DMI in ME and MP regimen. From comparison of results, the DCP and DE intake pooled for all groups increased by 38.6 and 31% respectively in lactation than gestation.

During lactation phase the does irrespective of dietary energy and protein levels lost weight ranging from 0.0l to 0.17 kg which was about 4.0% of their initial weight. The fat and energy balance is always negative in lactating does amounting to loss of about 25 to 30% of initial weight (XICCATO, 1996) whereas in this study such loss amounted to 4.0% of initial weight ascribed mainly to lower lactation yield of does in tropical condition (SINGH, 1996).

Gain in litter weight is a good indicator of milk yield in rabbits (COWIE, 1969) providing 0.56 kg gain per kg of milk consumed (PARTRIDGE and ALLAN, 1982). Calculated milk yield of the does in ME, HE and MP, HP diets was higher compared to LE and LP diets (Table 5). The calculated average milk yield of the does in these treatments groups was 99 g/d which is comparable with the observations of SINGH (1996) at same location on similar genetic group of rabbits.

In lactating does type of experimental diet has a considerable effect on litter weight at weaning. The weight gained by the kits during suckling was lower in LE and LP regimen compared to ME, HE, MP and HP diets (Table 5). By comparison of the calculated milk yield and litter weight at weaning it was apparent that except LE and LP diets, other diets were able to support desirable milk production during lactation and satisfactory weight of weaning kits. During lactation in general, does on ME, HE, MP and HP diets, consumed average 59 g DM, 8.5 g DCP and 160 kcal DE/kg $W^{0.75}$ and had satisfactory performance. It was apparent that on an average the diet having 18% CP and 2700 kcal DE/kg feed supported optimum production traits in tropics. The animal performance vis-à-vis the concentration of dietary protein and energy levels in the present study are on higher side compared to values reported for temperate countries (LEBAS, 1980; XICCATO, 1996). The lactation phase of the study was conducted under prevailing high ambient temperature condition (ambient temperature 40.7°C ; RH 16.6% at 14.30 h) and it is established that energy requirement of animal increases under hot condition (KAREM, 1991) due to enhanced energy requirement to dissipate body heat through respiratory ventilation and Vant Hoff's effect (CONSOLAZIO *et al.*, 1960).