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THE REQUIREMENTS OF DIGESTIBLE ENERGY, CRUDE PROTEIN AND AMINO ACIDS FOR ANGORA RABBITS

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Abstract

1,456 Angora rabbits at different physiological stages were used in 106 feeding experiments and 79 digestive experiments from 1986 to 1989 in order to determine the nutrient requirements of the rabbits. All diets involved were tested for the contents of digestible energy (DE) and digested crude protein (DCP). The intakes of DE, crude protein (CP), and DCP per day per rabbit were measured and the performances of the rabbits, including body weight, body weight gain, wool production, fertility, lactation and semen quality, were also recorded. Computer technique was used to analyze all the data in terms of variance analysis and regression analysis to work out the optimum contents of DE, CP, DCP, crude fibre, sulphur-containing amino acids and lysine in diets for growing rabbits (from weaning to 3 month of age and from 4 month to 6 month of age), pregnant does, lactating does, wool producing rabbits and stud bucks. The formulas have been made for estimating the requirements of DE, CP and DCP per day per rabbit with the different production levels and also , expressed these requirements in tables.
Key words: Angora rabbit, Nutrient requirement.

Introduction

1980s saw a rapid development of rabbit industry in China. The number rose up to nearly 100 millions by the end of 1988 including 55 millions of Angora rabbits and their crossbreeds with the annual wool production more than 1500 tons which ranks first in the world. Unfortunately however, the knowledge of rabbit nutrition was less available in the country. For improvement of production, the determination of the nutrient requirements of Angora rabbits were quite necessary and consequently this study was set up for this purpose.

Materials and Methods

This study was conducted in Lanzhou, Gansu Province and Nanjing, Jiangsu Province from 1986 through 1989. The experiments involved were as

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followings:

1. Growing rabbits

359 rabbits, aged from weaning to 3 months, in 22 groups were used in feeding and digestive tests for a period of 35 days, and 189 rabbits aged 4-6 months in 6 groups were used for the same purpose for a period of 42 days. The individual body weight and its changes were recorded for all rabbits.

2. Pregnant does

315 pregnant does in 22 groups, aged 1-3 years, were involved in the experiments of feeding, digestive and metabolism. The body weight and its changes during pregnancy, litter size, litter weight and the birth weight of baby rabbits were recorded.

3. Lactating does

147 lactating does in 21 groups used in the experiments of feeding, digestive and metabolism. The body weight and its changes of the does were measured during the lactation period. The milk production was measured by means of weighing does immediately before and after suckling. The young rabbits weaned 42 days after birth.

4. Wool producing rabbits

272 mature rabbits in 22 groups were used in feeding and digestive experiments for a period of 80-90 days. The body weight and its changes, wool yield were recorded.

5. Stud bucks

132 stud bucks, aged 1-3 years in 13 groups, were used in feeding and digestive experiments for 3 months. Semen was collected through the 3rd month in a pattern of one artificial collecting semen per day and stop for one day rest in every three days. The items tested were the amount of each ejaculation, the density and activity of semen, body weight and its changes.

All rabbits involved in the experiments were individually kept in single hutch, fed with pelleted diets ad libitum. The intake of the diets per day per rabbit was recorded and the average intakes of digestible energy (DEI), crude protein (CPI) and digested crude protein (DCPI) in each experiment was calculated according to the results of the digestive experiments which were carried out for 7 days during the middle time of each experiment. All the data were treated by computer for variance analysis and multiple regression analysis.

Results

1. The optimum contents recommended of DE, CP and DCP in diets

Diets with different contents of energy and CP were designed for the rabbits at each physiological stage. Significant differences ($P<0.05$) were observed between the groups in the average intakes ad libitum of DE, CP and DCP per rabbit per day as expected and the changes in the production performance of the rabbits occurred responding to those intakes. The optimum nutrient contents of the diets, as described in Table 1 to which the production performances responded, were thus selected according to the rabbit performance and feed costs.

2. The requirements of DE, CP and DCP per day

The production levels and farming conditions of Angora rabbits in China are changeable, which results in the changes in requirements of nutrients. The nutrient requirements per day are thus necessary for rabbit producers to adjust the composition and the amount of diets supplied. For this purpose,

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Table 1 The nutrient requirements of Angora rabbits — the nutrient contents recommended in diets

Items		Growing rabbit		Pregnancy	Lactation	Wool Production	Mating bucks
		Weaned-3 mon	4-6 mon				
Digestible energy	Kcal/kg	2500	2400-2500	2400-2500	2600	2400-2800	2400
Crude protein	%	16-17	15-16	16	18	15-16	17
Digested crude protein	%	12-13	10-11	11.5	13.5	11	13
Crude fibre	%	14	16	14-15	12-13	12-17	16-17
Ether extracts	%	3	3	3	3	3	3
DCP/DE	g/Mcal	50	45	48	52	46	54
Methionine + Cystine	%	0.7	0.7	0.8	0.8	0.7	0.7
Lysine	%	0.8	0.8	0.8	0.9	0.7	0.8
Arginine	%	0.8	0.8	0.8	0.9	0.7	0.9

all the data from the experiments were used to set up a model of linear regression between the intake of DE, CP and DCP (as regression response) and the production traits such as live weight (LW), daily live weight gain (DLWG), litter size or litter weight, milk yield and wool production (referred to regression factors). The factors found to be not significant for regression ($p>0.05$) were omitted from the equations and the regression formulas of calculating the requirements of DE, CP and DCP per day per rabbit were finally obtained as followings:

1.1 Growing rabbits (weaned to 3 months):

DE (kcal) = 0.119 LW (g) + 4.19 DLWG (g) - 25.5
CP (g) = 0.0046 LW (g) + 0.316 DLWG (g) + 1.53
DCP (g) = 0.0029 LW (g) + 0.259 DLWG (g) + 1.16

The DLWG of rabbits in southern China was found to be lower than that in northern China when same amounts of energy and protein were supplied. The reasons were unknown. To obtain the same DLWG, the CP supply were suggested to be increased by 9%, or DCP by 7% and DE increased by 3% respectively on the base of the data in Table 1 for the rabbits in southern China.

1.2 Growing rabbits (4-6 months):

DE (kcal) = 0.02 LW (g) + 3.144 DLWG (g) + 289
CP (g) = 0.0035 LW (g) + 0.199 DLWG (g) + 12.23
DCP (g) = 0.0023 LW (g) + 0.154 DLWG (g) + 8.91

1.3 Pregnant does:

DE (kcal) = 301 + 0.098 Litterweight (g) + 2.925 DLWG (g) + 0.015 LW (g)
CP (g) = 22.87 + 0.0136 Litterweight (g) + 0.156 DLWG (g)
DCP (g) = 16.38 + 0.0092 Litterweight (g) + 0.103 DLWG (g)

where, DLWG stands for the daily live weight gain of the does excluding the weight of the uterine contains.

A high correlation was found in the litter weight and the litter size and thus litter weight can be estimated with litter size as followings:

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Litter weight (g) = 48.17 + 44.53 Litter size

The average litter size of Angora rabbit was about 7 in our experiments, and the litter weight was thus 360 g averagely.

1.4 Lactating does:

DE (kcal) = 273 + 1.478 Milk yield (g) + 4.81 DLWG (g) + 0.031 LW (g)

CP (g) = 28.42 + 0.087 Milk yield (g) + 0.206 DLWG (g)

DCP (g) = 21.82 + 0.053 Milk yield (g) + 0.118 DLWG (g)

The milk yield per day can be measured directly or estimated using the following formula:

Milk yield (g/day) = 21.76 Kids suckled - 4.12

1.5 Wool producing rabbits:

DE (kcal) = 204 + 27.15 Daily wool cut (g) + 3.28 DLWG (g) + 0.031 LW(g)

CP (g) = 19.85 + 2.58 Daily wool cut (g)

DCP (g) = 14.45 + 1.71 Daily wool cut (g)

1.6 Stud bucks:

DE (kcal) = 306 + 18.27 Spermatozoon number (100 mil/ml) + 8.53 DWLG (g)

CP (g) = 19.97 + 3.07 Spermatozoon number (100 mil/ml) + 1.39 DWLG (g)

DCP (g) = 13.84 + 2.90 Spermatozoon number (100 mil/ml) + 1.06 DWLG (g)

These formulas were used to estimate the requirements of DE, CP and DCP per day per rabbit which were tabled in Table 2 to Table 4 including the estimated intakes of pelleted diets.

3. Crude fibre content in diets

It is known to all that the content of DE was influenced basically by CF contents in diets. The results from our 116 digestive experiments showed that the correlation between the DE content (kcal/kg) or DE (%) and the CF% in the diets were significantly negative when CF was at the range of 7.20-34.00%:

DE (kcal/kg) = 4701 - 828.47 LnCF ,

$n = 115$, $r = -0.867$, rsd = 113 Kcal;

DE (%) = 115.06 - 19.74 Ln CF,

$n = 116$, $r = -0.859$, rsd = 2.9%.

Therefore the CF content in diets can be basically determined when the optimum DE content has been selected as described in Table 1.

Discussion

Studies on the nutrient requirements of Angora rabbits in wool producing period has attracted many scientists in the world. Klaus (1985) believed that DE content, CP% and CF% in the diets should range between 2300-2600 kcal/kg, 15-17% and 14-16% respectively for the rabbits producing 1 kg wool per year. Rougeot (1984) suggested that the diets containing 2700 kcal/kg of DE, 16-17% CP, 12-13% DCP and 16-20% of CF should be fed for the rabbits producing annually more than 1 kg wool. Another result published showed that no significant differences were found in wool production and DLWG when the range of DE, CP and sulphur-amino acids were, respectively, 2507-2653 kcal/kg, 17.5-20.3% and 0.66-0.97% (Henies, 1988), and the diets with 13-19% CP had no significant effect on the length and fineness of the wool

Table 2 The nutrient requirements per day of growth rabbits, pregnant does and stud bucks

LW (kg)	DLWG (g)	Pelleted feed intake (g)	DE (kcal)	CP (g)	DCP (g)
Weaned - 3 months					
0.5	20	60-85	118	10.1	7.8
	25		139	11.7	9.1
	30		160	13.3	10.4
1.0	20	70-105	177	12.4	9.3
	25		198	14.0	10.5
	30		219	15.6	11.8
1.5	20	95-115	237	14.7	10.7
	25		258	16.3	12.0
	30		279	17.9	13.3
2.0	20	110-135	296	17.1	12.1
	25		317	18.6	13.4
	30		338	20.2	14.7
4-6 months					
2.5	10	150-160	370	23	16
	15		386	24	17
3.0	10	155-165	380	25	17
	15		396	26	18
3.5	10	160-170	390	27	18
	15		406	28	19
Pregnant does, 7 kids per litter, more than 2 g wool production per day, fetus not included in DLWG					
3.5-4.0	> 3	> 170	405	28	20
Stud bucks in mating period, more than 2 g wool production per day					
3.5-4.0	2	> 150	350	27	20

Table 3 The nutrient requirements of lactating does per day

LW (kg)	DLWG (g)	Milk yield (g/day)	Pelleted feed intake (g)	DE (kcal/kg)	CP (g)	DCP (g)
3.5	2	105	>210	546	38	28
		126		577	40	29
		152		616	42	30
4.0	2	105	>220	562	38	28
		126		593	40	29
		152		631	42	30

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Table 4 The nutrient requirements of wool producing rabbits per day

LW (kg)	DLWG (g)	Wool Production (g)	Pelleted feed intake (g)	DE (kcal)	CP (g)	DCP (g)
3.5	0	2	155-180	367	25	18
		3		394	28	20
		4		421	30	21
4.0	0	2	160-185	383	25	18
		3		410	28	20
		4		437	30	21

fibre (Caro, 1988). In this study, DE contents in diets ranged from 2308 kcal/kg to 2536 kcal/kg, and the intakes per day were 331-421 kcal. No significant differences were found between the groups, which suggested that the changes in DE contents at such a domain had no influence on wool production. Furthermore the contents of CP in the diets were increased from 14% to 20.7%, and the daily intakes of CP were 22.3-30.6 g but the wool production at the higher levels of protein was not increased correspondingly as expected. It would be possible that the rabbits involved in the experiments were not genetically high production in wool cut (185 g/80 days averagely).

Comparing our results with references we believe that for normal wool production by Angora rabbits, the diets with CP contents of over 17% have no advantages in increasing wool yield and instead increase the cost of diets. The range of DE contents could be rather larger in the diets from 2300 kcal/kg to 2700 kcal/kg. The diets with higher proportion of roughage may be more practical as it may prevent rabbits from suffering hairballs disease (Trichobezoars) (Cheeke et al., 1987).

In this study, the range of DE content in diets for the growing rabbits (weaned to 3 months and 4 to 6 months) was 2200-2600 kcal/kg , CP content 12.45% to 22.53%, and the corresponding DLWG were 17.6 g to 29.9 g. The summary of the results from the all 28 groups of the growing showed (1) that DLWG of the rabbits tended to be improved with the increase of DE contents in diets, but not significantly different ($p>0.05$) at the range of 2400 kcal/kg to 2600 kcal/kg, the corresponding DLWG being 25.8 g to 29.9 g with the average of 28.2 g; (2) that average DLWG was increased when the CP contents in the diets were raised from 12.45% to 17%, however the further increases of DLWG were slow down or not significant when CP percentage in diets was over 17% and the costs of gain were increased sharply. Therefore it was not proper to have CP content in diets over 17% for growing rabbits; (3) that after 3 month of age, the growing of the rabbits slowed down obviously. The DLWG was 10 to 17 g averagely. The relations between DLWG and the changes in DE content or CP content in the diets remained same as it was before 3 month of age with an exception that the decrease of nutritional level during this stage may cause the obvious reduction ($p<0.05$) in wool production.

Few reports has published on nutrient requirements of the growing Angora rabbits. The information available were mainly for meat rabbits as described in following: NRC (1977), CP 16%, DE 2500 kcal/kg, CF 10-12%; Lebas (1980), CP 15%, DE 2500 kcal/kg, CF 14%; Huang et al.(1987), CP 15%, CF 11%; Oinole (1982), CP 18-22%; Chnatal (1981), DE 2240-2760 kcal/kg, CP 16-19.2%, DCP 11.5%-14.2%; Lebas (1982), DE 2352-2930 kcal/kg. These data indicated that the proper DE content in diets for growing rabbits would be about 2500 kcal/kg, and CP 15-16%.

The important production traits of pregnant does are litter size, birth weight of kids as well as the nutrient storage in body during pregnancy, which could be mainly indicated by the changes in the body weight of the does excluding the weight of uterine weight. In this study, the DE contents of the diets for 22 groups of pregnant does were 2200 kcal/kg to 2700 kcal/kg. Under the condition of ad libitum, no significant differences were found in litter size , birth weight and maternal DLWG between the groups ($p>0.05$). The birth weight of the kids had, however, a tendency to decrease with the increase of DE intake, but still remained in normal range of 46 to 56 g averagely. This situations changed with seasons. In summer, the temperature was over 25^{0}C, the does obviously ate less and the diets with lower DE contents could not meet DE requirements for pregnancy. As the results, the birth weights of the young were decreased as well as the does themselves. So it was proper to feed does with higher DE diets in hot summer.

When the pregnant does had low CP diets the young had a lower birth weights. But when the intake of CP were over 28 g per day, the birth weights of the young stopped increasing and the body weights of the does were lost rapidly. The reason for this have remained unrecovered.

The contents of CP in diets had obvious effects on milk production of lactating does. The higher the intake of CP was, the higher milk was produced and the heavier the young rabbits were at weaning. The body weights of the does, however, had a tendency of decreasing. The positive correlations were found between the DE contents in the diets or the DE intake and the milk production and the body weight gain of the does in this experiments. The higher the intake of DE was, the more obviously the body weight of does increased during the whole lactating period. It was noteworth that during the 5-week-lactation period, the changes in the body weight of the does fluctuated from week to week. And higher nutrient supply could help to delay the catabolism of nutrient storage in the body, and therefore would help to improve milk production and supply sufficient nutrients for the does which got pregnant during lactation period.

Up to now, few reports have been found referring to the effect of nutritional levels on semen quality. In this study the diets with 2200-2500 kcal/kg of DE, 13.67-22.72% of CP were fed to the stud bulk for three months. We found (1) that nutritional level had no significant effect on semen volume ($p>0.05$) but had effect on semen density, especially the intake of protein affected significantly semen density ($P<0.05$). When CP content in the diets were over 17%, the improvement of semen density by increasing of protein intake became not so obvious. The intake of DE mainly affected on the body weight changes. During the mating season, the stud bucks with low DE intake would lose more weight; (2) that the pelleted diet intake of the bucks was comparatively stable, being about 150 g per day. (3) that temperature had great effect on the quality of semen and this was always accompanied by attenuations of feed intake. When the temperature was over 25°C with high humility, the intake and the semen density reduced remarkably, lower in sexual virility but no significant differences in the semen volume. This kind of situation is most common in south part of China. In northern part of China, however, the case was not such worse because the climate is dry and in summer the period of high temperature is very short during the day and there is a large diurnal variations of temperature although the highest temperature can be up to 34°C . The semen density had slight tendency of decreasing but not significantly difference. The semen activity and reproduction could go normal and no remarkable attenuation in intake was found.

It should be pointed out that the wool growing period of the Angora rabbits lasts 70 to 90 days and this has some effects on feed intake. The intake was higher during early stage than later stage. The thickness of wool had significant effect on energy metabolism and then nutrient requirements. Because the pregnant period or lactating period of rabbits lasts about one month, this kind of influence therefore could not be negligible and it should be considered carefully.

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