EFFECTS OF DIFFERENT PROTEIN, FIBRE AND ENERGY LEVELS ON GROWTH PERFORMANCE AND THE DEVELOPMENT OF DIGESTIVE ORGANS IN GROWING MEAT RABBIT

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ABSTRACT

Six groups of 40 New Zealand White rabbits, each were reared from 30 days of age on diets containing different protein, fibre and energy were used to study influences on productive performance, the development of digestive organs, biochemical and hormonal parameters of rabbits. Six groups were fed on diet A (control group), diet B (higher protein group), diet C (higher energy group), diet D (higher energy and lower fibre group), diet E (higher protein and energy group) and diet F (higher protein and energy with lower fibre group), respectively. The results showed that the average daily gain of rabbits fed on diet A, B, C, D, E and F was 22.8, 26.9, 24.7, 21.5, 28.1 and 24.5g, respectively, while the feed/gain rate was 3.6, 3.0, 3.2, 3.5, 2.7 and 3.1, respectively. This might suggested that higher protein, energy and fibre diet could increase the average daily gain and decrease the feed/gain rate. Rabbits fed on diet F had the highest relative weight of stomach, followed by diet B, A, C, E, and D, were 71.4, 67.1, 64.9, 53.8, 52.5, 52.3 g/kg, respectively. Rabbits fed on diet A had the highest relative weight of small intestinal contents, followed by diet C, E, F, B and D, were 58.0, 56.0, 52.8, 47.3, 46.3, 44.5 g/kg, respectively. Rabbits fed on diet A had the highest relative weight of caecum, followed by diet D, F, E, C and B, were 107.3, 98.6, 96.4, 88.4, 79.5, 76.2 g/kg, respectively. These suggested that the relative weights of stomach, small intestinal contents and caecum were significant affected by different protein, fibre and energy levels ($p<0.01$ or 0.05). However, there were no significant changes in the relative weights of stomach contents, small intestine and caecum contents ($p>0.05$). The activities of small intestine trypsin of rabbits fed on diet C were higher than those of other diets followed by diet A, D, F, E and B ($p<0.05$). However, no significant changes in the activities of small intestine amylase and lipase were observed ($p>0.05$). The values of plasma total protein, albumin, Albumin/Globulin ratio, glucose, total cholesterol and urea nitrogen revealed non-significant changes among all groups that received different dietary treatment ($P>0.5$).

Key words: Protein, fibre, energy.

INTRODUCTION

Dietary protein, fibre and energy levels are the three most important factors which impact rabbit performance. Therefore, an attempt should be directed to detect the exact levels of protein, fibre and energy without lowering the rabbit performance. The nutritional requirements for rabbits various production functions (growth, gestation and lactation) are limited (Yassein *et al.*, 2011). Crude protein (CP) is the most common unit used to express nitrogen requirements and the nutritive value of feedstuffs. Now the dietary CP requirement of growing rabbits is about 15.5% (De Blas and Wiseman, 2010). Our previous research concluded that increasing protein level in the rabbit diets improve productive efficiency (Li F.C. *et al.*, 2002). It is expected that great efforts will be directed to maximize the utilization of low-protein diet for rabbits.

The energy concentration of rabbit diets varies widely. It has been reported that dietary CP contents of around 140 g kg^{-1} do not impair growth performance if the digestible protein (DP) : digestible energy (D digestible protein E) ratio is maintained around 9.5-10 g MJ^{-1} and the amino acid supply is adequate (De Blas and Wiseman, 2010). On the other hand, an excess of protein content related to energy increases environmental pollution (De Blas and Wiseman, 2010). Several studies (De Blas and Wiseman, 2010) have also observed that a reduction in dietary protein content or the use of highly DP sources decreases ileal protein flow and reduces the proliferation of pathogens and mortality during the fattening period.

Fibre is one of the main constituents of commercial diets for intensively reared rabbits, which typically include around one-third of forages and fibrous by-products. The difficulty in reaching agreement on the concept of dietary fibre is based on its complex physical structure and the chemical composition of cell walls, the considerable diversity of cells types that constitute different plant tissues and the wide and different physiological effects of the different constituents (De Blas and Wiseman, 2010). Although the role of fibre in rabbit nutrition is not limited to nutrient supply, it plays a major role in the regulation of rate of passage of digesta, the control of gut flora and the maintenance of intestinal mucosa integrity (De Blas and Wiseman, 2010). So, fibre is essential to maintain gut health, stimulate gut motility (insoluble fibre only), and reduce fur chewing (Irlbeck, 2001). Now the dietary crude fibre (CF) requirement of growing rabbits is 16.6%, range from 12.2% to 24.4%. Low-fibre diets result in gut hypomotility, reduced caecotrophe formation, and prolonged retention time in the hindgut (Irlbeck, 2001). Now some investigators suggested increasing fibre level in rabbit diets in order to reduce gut disease. Fibre constituents are a main energy source for caecal microorganisms, so that an effect both of level and type of dietary fibre on the amount of microbial protein recycled daily throughout soft faeces, might be expected (De Blas *et al.*, 1999).

The objective of the present study was to investigate the response of rabbits to different protein (16% and 20%), fibre (from 9.8% to 14%) and energy (from 10.3 to 11.7 MJ/kg) levels on growth performance and the development of digestive organs in weaning-2.5 month growing New Zealand White rabbits.

MATERIALS AND METHODS

Animals and diet

A total of 240 weaned crossbred New Zealand White rabbits (30 day old and mean body weight 0.61±0.18kg, males and females had half each) were used in this study. Rabbits were divided randomly into six groups according to average weight with 40 rabbits in each group.

The diets were formulated with higher or lower in protein, fibre and energy according to the requirements of growing rabbits (De Blas and Wiseman, 2010). Each group was fed with one of 6 different diets noted A, B, C, D, E and F, respectively, and the data of the composition were calculated and shown in Table 1.

The feed was pressed using a pellet mill into pellets with diameters of 4 mm. Does were housed individually in flat-deck cages (700mm×500mm×320mm) with automatic drinkers with nipples. During the trials, the rabbits were housed in a closed and ventilated building in which the maximum temperature was 28 °C, the minimum temperature was 10 °C and the relative humidity ranged from 50% to 60%. A cycle of 12 h from 6:30 to 18:30 of light and 12 h of dark was used throughout the trial.

Experimental procedures

Experimental periods consisted of a 7-days adjustment period followed by a 35-days experimental period. Body weight, weight gain and feed/gain (F/G) ratio were measured weekly following the method of Li *et al*., 2002. After feeding trial, 6 rabbits from each group were slaughtered following the

method of Zhang *et al*., 2011, and the weight of stomach, small intestine, caecum and their contents were measured. The activities of small intestine amylase, trypsin and lipase in rabbits were measured using the kits following the instruction (Nanjing jiangcheng Bioengineering Institue, China). Blood samples were collected from marginal ear vein of each treatment into heparinized tubes to determine some biochemical and hormonal studies following the method of Zhang *et al*., 2011. The biochemical parameters included: total protein, albumin, albumin/globulin ratio, glucose, total cholesterol and urea nitrogen (UN) were measured using kits according to the instruction (Nanjing jiangcheng Bioengineering Institue, China).

Table 1: Ingredients and composition of experimental diets.

	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F
Ingredients (%):						
Corn	24	13.5	25	30	21	28
Soybean meal	13.7	23.7	17.3	12.8	28.3	24.5
Peanut vine	41	40	43.5	24	43.9	25.7
Wheat brean	19.5	21	6.4	30.4	0	20
Soybean oil	0	0	6	1	5	0
NaCl	0.5	0.5	0.5	0.5	0.5	0.5
Bone-meal	1	1	1	1	1	1
L-lysine	0.15	0.15	0.15	0.15	0.15	0.15
DL-methionine	0.15	0.15	0.15	0.15	0.15	0.15
Premix[1]						
Composition (%):						
CP	16.0	20.0	16.0	16.0	20.0	20.0
EE	2.9	2.7	8.4	4.1	7.3	2.8
CF	14.0	13.9	14.0	9.8	14.0	10.0
DE (MJ/kg)	10.3	10.3	11.7	11.7	11.6	11.5
Ca	0.4	0.4	0.4	0.4	0.4	0.4
P	0.5	0.6	0.4	0.6	0.4	0.6

[1]Premix Provided following per kg of diet: VA 8 000 IU; VD_3 1 000 IU; VE 50 mg; Cu 50 mg; Fe 100 mg; Mn 30 mg; Mg 150 mg; I 0.1 mg; Se 0.1 mg.

Statistical analysis

Statistical significance was determined by ANOVA analysis using SPSS program. Differences were considered significant at $P < 0.01$ or $P < 0.05$ by Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Productive performance data of average daily gain (ADG), average daily feed intake and F/G rate of rabbits is influenced by dietary protein, fibre and energy levels were shown in Table 2. The ADG of rabbits fed on diet A, B, C, D, E and F was 22.8, 26.9, 24.7, 21.5, 28.1 and 24.5g respectively, and diet B (CP: 20%) was 18.0% higher than A (CP: 16.0%) at the same high CF and low DE levels, F was (CP:20%) 14.0% higher than D (CP: 16.0%) at the same low CF and high DE levels, C was (CF: 14%) 14.9% higher than D (CF: 9.8%) at the same low CP and high DE levels, E was (CF: 14%) 14.7% higher than F (CF: 10%) at the same high CP and high DE levels, C (DE: 11.7) was 8.3% higher than A (DE:10.3) at the same low CP and high CF levels, and E was (DE: 11.6) 4.5% higher than B (DE:10.3) at the same high CP and high CF levels, while the F/G rate was 3.6, 3.0, 3.2, 3.5, 2.7 and 3.1, respectively.
(2011).

Table 2: Comparison of productive performance of weaning-2.5 months old rabbits fed with 6 different diets.

Parameters	Traits						MSE[1]	*P Value*
	A	B	C	D	E	F		
Average daily gain (g)	22.8^{b}	26.9^{ab}	24.7^{ab}	21.5^{b}	28.1^{a}	24.5^{b}	3.586	0.0395
Average daily feed intake (g)	83.3	78.6	77.5	76.8	78.7	75.4	2.899	0.2380
Feed/gain rate	3.6^{a}	3.0^{ab}	3.2^{ab}	3.5^{a}	2.7^{b}	3.1^{ab}	0.550	0.0484

[1]MSE: root-mean-square error.

Moreover, no significant difference was detected for the average daily feed intake in all groups. Our results were similar to those reported by De Blas *et al.* (1999), Dias *et al*. (2000), Li *et al*. (2002) and Yassein *et al*.

The relative weights of stomach, small intestine, caecum and their contents of rabbits were shown in Table 3. As shown in table 3, the relative weight of stomach of rabbits fed on diet F was higher than those of other diets, followed by diet B, A, C, E, and D, respectively. The relative weight of small intestinal contents of rabbits fed on diet A was 3.6%, 9.8%, 22.6%, 25.3% and 30.3% higher than C, E, F, B and D, respectively. The relative weight of caecum of rabbits fed on diet A was 8.8%, 11.3%, 21.4%, 35.0% and 40.8% higher than D, F, E, C and B, respectively. The relative weight of stomach of rabbits fed on diet F was 6.4%, 10.0%, 32.7%, 36.0% and 36.5% higher than B, A, C, E and D, respectively. However, the relative weights of stomach contents, small intestine and caecum contents were no significant changes in all diets ($P>0.05$). The results suggest that the amount of CF consumed the optimal dietary fibre level was 14% since the fibre is the most essential nutrient for rabbits. The results were similar to those reported by Tao and Li (2005) and Chao *et al.* (2008).

Table 3: The relative weight of digestive organs and their contents of rabbits was affected by different dietary nutrition levels.

Relative weight (g/Kg)	Traits						MSE[1]	P Value
	A	B	C	D	E	F		
Stomach	64.9^{ab}	67.1^{a}	53.8^{b}	52.3^{b}	52.5^{b}	71.4^{a}	8.079	0.0140
Stomach contents	15.4	15.6	16.3	15.1	14.9	16.1	0.910	0.2946
Small intestine	85.4	64.9	66.7	55.1	73.2	69.2	12.80	0.0757
Small intestinal contents	58.0^{A}	46.3^{BC}	56.0^{A}	44.5^{C}	52.8^{AB}	47.3^{BC}	4.284	0.0013
Caecum	107.3^{A}	76.2^{C}	79.5^{C}	98.6^{AB}	88.4^{BC}	96.4^{AB}	8.999	0.0011
Caecum contents	28.5	26.5	26.2	28.1	26.5	26.0	2.376	0.5876

[1]MSE: root-mean-square error.

The activities of small intestine amylase, trypsin and lipase in rabbits are presented in Table 4. The data show that the activities of small intestine trypsin of rabbits fed on diet C were 63.4%, 92.3%, 102.1%, 184.9% and 217.6% higher than diet A, D, F, E and B, respectively, while there were no significant changes in the activities of small intestine amylase and lipase. These results confirmed those of previous experimental results (Li *et al.*, 2004).

Table 4: Enzyme activities in small intestine of rabbits was affected by different nutrition levels.

Activities (U/g)	Traits						MSE[1]	P Value
	A	B	C	D	E	F		
Amylase	1.4274	0.6054	2.4391	2.2310	0.7477	1.2323	1.086761	0.1765
Trypsin	60417^{ab}	31087^{b}	98725^{a}	51333^{ab}	34649^{b}	48860^{b}	26731.84	0.0355
Lipase	3973	5758	26237	33933	12303	12303	13143.31	0.0687

[1]MSE: root-mean-square error.

The data of protein profile, glucose, total cholesterol and UN level of rabbits in all groups were presented in Table 5, which can reflect the effect of dietary nutrient level on metabolism and obsorption. It is evident that the values of plasma total protein, albumin, Albumin/Globulin ratio, glucose, total cholesterol and UN revealed non-significant changes between all groups ($P>0.5$). This result is closely associated with those previously recorded in rabbits by Yassein *et al.* (2011).

Table 5: Protein profile, glucose, total cholesterol and UN level of rabbits fed on different dietary nutrition levels.

Parameters	Traits						MSE[1]	P Value
	A	B	C	D	E	F		
Total protein (g/L)	50.50	51.83	55.17	53.83	52.50	55.80	8.052	0.8703
Albumin (g/L)	24.33	26.17	29.00	28.17	27.33	28.00	4.292	0.4874
Albumin/Globulin	0.94	1.03	1.11	1.10	1.10	1.01	0.128	0.2068
Glucose (mmol/L)	5.23	6.05	6.58	4.80	4.98	4.98	1.191	0.0903
Total cholesterol（mmol/L）	1.39	1.57	1.18	1.19	1.33	1.46	0.471	0.6830
Urea nitrogen (mmol/L)	8.55	9.60	7.62	9.92	14.53	10.88	3.677	0.0591

[1]MSE: root-mean-square error.

CONCLUSIONS

The productive performance and the development of digestive organs were significant affected by dietary protein, fibre and energy levels. Higher protein and energy levels diet could increase the ADG and decrease the F/G rate. The development of digestive organs was significant affected by dietary fibre levels, and rabbits were fed on lower fibre diet resulted in diarrhoea and death (data not shown). In conclusion, the appropriate CP, CF and DE requirement of growing rabbits from weaned to 2.5-month-old was 16%, 14% and 11.7 MJ/kg on the basis of ADG, F/G and UN under this experiment condition.

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