Proceedings 5th World Rabbit Congress, 25-30 July 1992, Corvallis – USA, 1640-1645.

THE EVALUATION OF NUTRITIVE VALUES OF THE FEEDSTUFFS AND DIETS FOR ANGORA RABBITS-- 2. THE PREDICTION OF THE CONTENTS OF DIGESTIBLE ENERGY AND DIGESTED CRUDE PROTEIN IN FEEDSTUFFS AND DIETS

Liu S.M., L. Zhang*, C. Chang, D.H. Pen and Z. Xu

Lanzhou Institute of Animal Science of Chinese Academy of Agricultural Sciences, Lanzhou, 730050, P.R.China

Y.Z. Wang, Q. Chen, W.J. Cao and D.Z. Yuan

Institute of Feed and Food of Jiangsu Academy of Agricultural Sciences, Nanjing, 210014, P.R.China

Abstract

145 sets of digestive trials with total faeces collection method were carried out using adult Angora rabbits for determination of digestible energy and digested crude protein of feeds. The chemical compositions, contents of digestible energy and digested crude protein in 145 diets and 84 species of feeds were tested. Based on these data, the formulas of predicting the contents of digestible energy and digested crude protein of protein feeds, energy feeds, fresh feeds, roughages and diets by chemical compositions were set up with the multiple regression analysis technique.
Key words: Angora rabbit, Feed, Digestible energy, Digested crude protein.

Introduction

Up to date, there is a lack of available data on the digestible energy (DE) of feedstuffs for rabbits (Maertents et al., 1988). Some experiments were carried out in other countries to estimate the content of DE by chemical compositions, but a few of these formulas used were qualified to be accepted in rabbit production. In China, only a few kinds of feeds have been studied, which can not meet the requirements of rabbit production. To solve this problem, this study was conducted from 1986 to 1988 for establishing the formulas of predicting the DE and DCP of feeds for Angora rabbits.

Materials and Methods

This study was conducted in Lanzhou and Nanjing, China including 145 sets of digestive trials on adult Angora rabbits. Digestive experiments with total faeces collection were accepted for testing the DE and DCP of feeds. The means, standard deviation and ranges of the compositions and nutritive values of 145 diets were listed in Table 1.

*: To whom correspondence should be addressed.

Table 1 The means and ranges of compositions and nutritive values of 145 diets

-	OM %	CP %	CF %	GE kcal/kg	DE kcal/kg	DCP %
X ± s	84.96 ±2.72	15.28 ±3.23	14.98 ±3.22	3914 ±195	2418 ±220	10.63 ±2.77
Range	78.63–88.37	8.42–23.87	7.20–34.00	3388–4346	1910–3219	3.20–18.43

OM, organic matter; CP, crude protein; CF, crude fibre;
GE, gross energy; DE, digestible energy; DCP, digested crude protein.

The following model was accepted for estimating DE and DCP contents of the diets and feeds:

$$Y = A + f_1(CP) + f_2(CF) + f_3(GE) + f_4(OM) \qquad (1)$$

where, Y = DE or DCP content of the feeds or diets,
CP = crude protein content of the feeds or diets,
CF = crude fibre content of the feeds or diets,
GE = gross energy content of the feeds or diets,
OM = organic matter content of the feeds or diets, and
f = the functional relationship of the Y with the compositions.

If the relationship between Y and each regression factors is linear, the model can then be changed into a multiple linear regression model as followings:

$$Y = A + B_1\ CP + B_2\ CF + B_3\ GE + B_4\ OM \qquad (2)$$

Considering the characteristics of the regression methods, the compositions of the diets were controlled for (1) making the range of each variable, that is each composition, have a proper gradient changes, especially for factors of CP and CF; and (2) making the compositions of the diets to be as similar as those used in practical production. Stepwise regression method was used for setting up the regression equations with computer and the compositions which have no significant contributions ($p>0.05$) to the regression estimation were omitted.

Results and Discussion

1. The estimation of DE and DCP contents of different type of feedstuffs

The contents of CF, CP, GE and OM of the feeds were mainly considered as regression factors for estimating DE and DCP as those information are usually included in the Tables of Compositions and Nutritive Values of Chinese Feeds. It is thus easy to access those available data for rabbit production. The regression equations established by this experiment were listed in Table 2 and 3 for protein feeds, energy feeds, fresh feeds and roughages respectively.

The Table 2 showed that DE content of the feeds was significantly affected ($p<0.01$) by CF and GE, but not by CP and OM ($p>0.05$). There was a positive correlation between DE and GE and strong negative correlation between DE and CF ($p<0.01$). Furthermore, this kind of negative relation

Table 2 Regression equations for estimating the digestible energy content (DE, kcal/kg) of the feeds

Type of feeds	Regression equations	R	rsd	n	CF range (%)	GE range (kcal/kg)	Source*
Protein feeds	DE = 1730 - 558.24LnCF + 0.871GE - 32.88CP	0.805	406	17	0.31-29.00	4384-6292	1+2
	DE = 297 - 25.94CF + 0.778GE	0.903	215	11	1.00-29.00	4384-5591	1
	DE = -214 - 37.03CF + 0.723 GE				0.31-23.90	4519-6292	2
Energy feeds	DE = 886 - 114.53CF + 0.812GE	0.959	150	10	5.20-11.68	3808-4526	1
	DE = 3516 - 35.62CF				1.00-12.91	4186-4615	2
Fresh feeds	DE = 70 - 78.20CF + 0.887GE	0.987	75	9	0.52-12.26	218-1594	1
Roughages	DE = 5914 - 1249LnCF	0.885	259	23	13.53-52.04	3552-4792	1+2
	DE = 4563 - 1636LnCF + 0.642GE	0.921	218	16	15.27-52.04	3552-4453	1
	DE = 1904 + 13.05CF				13.53-45.71	4017-4792	2

1. *: data from Lanzhou Institute of Animal Science; 2: data from Institute of Feed and Food; 1+2: data from the combination of the two sources.
2. CF, crude fibre, %; CP, crude protein, %; GE, gross energy, kcal/kg; all are based on dry matter except for the fresh feeds on fed state.
3. R: multiple regression correlation; rsd: residual standard deviation; n: sample size; Ln: natural logarithm.

Table 3 Regression equations for estimating the digestible crude protein content (DCP,%) of the feeds

Type of feeds	Regression equations	R	rsd	n	CF range (%)	CP range (%)	Source
Protein feeds	DCP = 0.805CP - 2.626LnCF - 2.66	0.981	2.82	17	0.31-29.00	22.11-80.20	1+2
	DCP = 0.686CP - 1.097LnCF + 3.71	0.982	1.93	11	1.00-29.00	22.11-63.81	1
	DCP = 0.632CP - 0.71CF + 12.62				0.31-23.90	32.91-96.31	2
Energy feeds	DCP = 0.917CP - 0.424CF + 0.65	0.974	1.03	9	3.52-11.68	4.87-17.45	1
	DCP = 0.407CP + 0.092CF + 2.14				1.00-12.91	7.05-21.11	2
Fresh feeds	DCP = 0.656CP - 0.23	0.884	1.75	10	0.52-12.26	0.68-5.03	1
Roughages	DCP = 0.772CP - 1.85	0.934	1.58	23	12.09-46.97	4.62-22.33	1+2
	DCP = 0.795CP - 2.15	0.926	1.76	17	12.09-46.97	4.62-22.33	1
	DCP = 0.476CP - 0.009CF + 1.36				13.53-45.71	5.24-20.56	2

Proceedings 5th World Rabbit Congress, 25-30 July 1992, Corvallis – USA, 1640-1645.

appeared linear in protein, energy and fresh feeds and changed into unlinear, logarithmic curve in roughages when their CF contents varied from 15% up to the maximum of 52.04%. This change indicated that the decreased extent of DE content by increasing CF content tended to become weak with the rise of the CF content and implied that rabbits have an ability, though it is quite weak, to utilize roughages with quite poor quality. From these equations, it could be estimated that the attenuation of DE content by every 1% increase of CF ranged from 26 kcal/kg to 115 kcal/kg, varying with feed type and CF content. The less content DE was, the more remarkable the effect of CF was on DE content.

The regression equations for estimating the DCP content of feeds were listed in Table 3. The relationships between DCP content and the compositions were quite different with that of DE. CP content accounted for the most variation of DCP and the changes in CF content had a relative small influence. The dominant determination of DCP by CP content could also be observed from formula recommended by NRC (1977), which showed that DCP (%) = 0.85 CP(%) - 2.5.

2. The estimation of the DE and DCP contents of diets

DE and DCP contents of feeds are the basic data of formulating diets for rabbits. Generally the DE or DCP content of each feed are considered to be linearly additive in diets. This foundation is however underlined by the facts (1) that there are interactions among nutritive values of feeds, which are associated with the interactions among nutrients; (2) that the DE and DCP contents of the given feed is tested under a specific condition with a given basic diet as well as a specific substitute proportion of the feed for basic diets. Varying in either the substitute proportion of the feed or the basic diet can, therefore, cause the varying of DE and DCP contents of the feed under testing. In short, the conditions under which the feed is evaluated are different, to some extent, with the conditions of practical production.

Direct estimation of nutritive values of diets could make this dilemma simple because the nutritive interactions among feeds occur and are involved in the values of diets. Another advantage is the compositions of diets are less variable, more balanced and similar to diets used in practice than single feed diets as long as the diets are designed carefully. And more important, all data from diets are directly measured rather than that indirectly calculated like the nutritive values of feeds. Thus the relationship between DE or DCP and compositions of diets would be more believable. On such a ground, the data from our all 145 sets of digestive experiments with 145 different diets were summed and the regression equations were worked out for estimating DE and DCP contents of diets. These formulas were listed in Table 4.

The general relationship between DE or DCP and compositions of the diets was similar to that between feeds, that the variations of DE content were mainly dominated by changes in CF and GE contents though the regression coefficients were different among feed types. The variations of CP content remained no significant effect on DE. Moreover, in our study a unlinear relationship between DE and CF was found and this was different with reports from other sources (NRC, 1977; Fekete et al., 1986; Sandford, 1986; Ding et al., 1988). In those experiments, a linear regression was uniformly confirmed. We deduced that this difference may stem from different ranges of CF contents in diets. In the present experiments, CF contents went up to more than 30%, the case being usual in the countryside of China. The decreased response of DE content to the increased CF tended to become weak at such high CF diets.

Table 4 Regression equations for estimating the digestible energy content (DE, kcal/kg) of the diets

Regression equations	R	rsd	n	Source
DE = 3317 - 792LnCF + 0.332GE	0.884	107	115	1
DE = -507 - 27.53CF + 0.88GE	0.882	95	30	2
DE = 666 - 51.34CF + 0.644GE	0.870	110	145	1+2
DCP = 0.814CP - 1.89	0.964	0.77	115	1
DCP = 0.891CP - 2.73	0.977	0.48	30	2
DCP = 0.83CP - 2	0.965	0.73	145	1+2

It was quite interesting that the analysis of regression and correlation showed that changes in CF content had no significant contributions ($p>0.10$) to DCP content in diets in our experiments. This implied that rabbits, as one species of monostomach animals, digest CF in diets with a special mechanism which is quite different with other monostomach animals. Cheeck and other European researchers believed that the caecum of rabbits could separate large particles (fibre) and small particles (non-fibre). The large particles are excreted rapidly and the small ones are retained for further digestion. In addition, the habit of coprophagy could also improve the digestion of the small particles. It would be this kind of re-digestion that makes the digestibility of CP in diets stable with being less influenced by the CF.

Besides of CF, other compositions, such as ash, organic matter (OM), had been accepted for prediction of DE content in diets by other workers. Ding et al.(1988) measured DE contents of 9 diets and found that DE could be predicted by GE, CF and CP contents. CF and ash as regression factors were accepted by Fekate et al.(1986). After measured DE contents of 81 diets and analyzed the data of 31 diets with multiple regression, Maertent et al.(1988) concluded that the fibre fractions, such as acid detergent fibre (ADF) or CF, still were the best factors for estimating DE content in diets and the effect of CP could be negligible statistically ($p>0.10$). The effects of OM on DE content was similar to that of GE, however only one of them could be accepted in multiple regression analysis as they were highly correlated each other, and higher accuracy of the regression equations was obtained with GE as an independent variable rather than OM. Because the energy contents of protein and fat are higher than carbohydrates, the variations in GE content actually reflect the changes in fat or/and protein content. The GE in diets was thus reasonably choiced in the present analysis.

Comparing the Table 2, 3 and 4, it could be seen that the residual standard deviations (rsd) of regression equations for the diets were smaller than that for feedstuffs with the variation coefficients of 4.5% for DE and 6.86% for DCP respectively. These accuracies could be satisfied for practical production.

Reference

1. Cheeke, PR; Patton NM; Lukefahr SD; and McNitt JI; 1987, Rabbit Production, IPP, Danville, Illinois, p.115.
2. Ding XM; Wu L; Hang LY; Can GX; Zhou XY; and Lu ZN; 1988, Studies on the estimation of digestible energy content of diets for wool rabbits, Chinese J. Anim. Sci., 1:4-7.

3. Fekete F; 1986, J. Appl. Rabbit Res., 9(3):103-108.
4. Lebas F; 1988, Rabbits, Livestock Production Science, 19:289-290.
5. Liu SM; Zhang L; Chang C; Lu YX; Wei CM; and Pen DH;, 1990, Chinese J. Rabbit Farming, 1:20-24.
6. Maertents L; Moermans R; and Groote De; 1988, Prediction of the apparent digestible energy (ADE) content of commercial pelleted feed for rabbits, J.Appl. Rabbit Res., 11(2):60-67.
7. NRC, 1977, Nutrient Requirements of Rabbits, 2nd edition, Washington DC, p.17.
8. Parigi-Bini R; 1988, Nutr.& Path., 4th Con. World Rabbit Sci. Assoc., Budapest, Hungary, p.14-28.
9. Sandford FC; 1986, The domestic Rabbit, 4th edition, London, p.107.