WORLD RABBIT SCIENCE 1998, VOL. 6 (2), 237-240.

HIGH LUCERNE DIETS FOR GROWING RABBITS

FERNANDEZ-CARMONA J., BERNAT F., CERVERA C., PASCUAL J.J.

Dpt. Ciencia Animal, Universidad Politécnica, 46071- VALENCIA, Spain

ABSTRACT : The topic is a study of rabbit production based on lucerne, using three diets: diet 1, a commercial composition having 11.4 kJ* g dry matter (DM) of digestible energy (DE) and 18.1 % DM crude protein (CP); diet 2, 96% lucerne with 9.0 kJ DE and 17.1 % CP; diet 3, 88.1% lucerne and 8.9% animal fat, with 10.1 kJ DE and 15.6% CP. The diets were used in fattening 289 weaned rabbits from 35 to 70 days old. Daily liveweight gain, feed conversion ratio and mortality rate for the three diets were significantly different: 40.3 g, 2.8 and 18.7 % (diet 1); 37.3 g, 3.7 and 8.4 % (diet 2); 37.2 g, 3.3 and 5.1 % (diet 3). Diet 1 was linked to a lighter gastrointestinal tract, stomach and stomach contents. Dressing out percentage was 57.8 (diet 1), 55.4 (diet 2) and 57.2 (diet 3): animals on diet 2 had a lower dressing percentage. Caecum volume and contents were lower for diet 3. Perirenal fat was significantly different for the three diets: 15.6 g (diet 1), 11.4 g (diet 2) and 23.1 g (diet 3)

RESUME : Régime riche en luzerne pour lapins en croissance.
La production du lapin basée sur l'utilisation de la luzerne est le but de cette étude. Trois régimes ont été utilisés : un aliment du commerce (1) dont l'énergie digestible (DE) est de 11,4kJ par g de matière sèche (DM), le taux de protéines brutes (CP)/matière sèche de 18,1 %; un aliment (2) avec 96 % de luzerne contenant 9,0kJ énergie digestible et 17,1 % de protéines brutes ; un aliment (3) avec 88,1 % de luzerne et 8,9 % de graisse animale contenant 10,1 kJ d'énergie digestible et 15,6 % de protéines brutes. Ces aliments ont été utilisés pour l'engraissement de 35 à 70 jours de 289 lapins sevrés. Le gain de poids vif journalier, l'indice de consommation et le taux de mortalité sont significativement différents pour chacun des trois régimes : 40,3g ; 2,8 et 18,7 % (aliment 1) ; 37,3g, 3,7 et 8,4 % (aliment 2) ; 37,2 ; 3,3 et 5,1 % (aliment 3). Un tractus digestif, un estomac et un contenu stomacal plus léger caractérisent l'aliment 1. Le rendement à l'abattage a été de 57,8 (aliment 1), 55,4 (aliment 2) et 57,2 (aliment 3). Le volume et le contenu du caecum ont été plus faible pour l'aliment 3. Le gras périrénal varie significativement selon les aliments : 15,6g (1), 11,4g (2) et 23,1 g (3).*

INTRODUCTION

One justification for rabbit production is the use of forage crops on a large scale, but in practice only 30 to 50% is included in the diets, the rest of the diet being made up of bran, cereals and protein concentrates. Few results are available for forage-only diets. The forage used was not pelleted in a large part of these trials, and in other occasions its low quality or poor food conversion ruled out commercial use.

Lucerne is the most widespread forage crop. It is normally included in rabbit diets and has relatively high average quality, although this may vary a great deal. The most relevant drawbacks of lucerne are its energy value, aminoacid deficiencies and mineral unbalance. The digestible energy value of lucerne, expressed in kJ (g DM)$^{-1}$ varies widely according to the authors, from 9.15 to 11.95 (LEBAS, 1987), 7.5-9.2 for lucernes with 25-29% CF according to the review by FERNANDEZ-CARMONA *et al.* (1996), 7.8-10.7 in the 12 samples analysed by PEREZ (1994) and 6.4-9.2 in 5 samples harvested at different stages of maturity, analysed by GARCIA *et al.* (1995a).

It appears that the energy needs of commercially-crossed rabbits cannot be met exclusively with lucerne, on account of a physical limitation in ingestion. MAERTENS and DE GROOTE (1981) observed an acceptable DE intake when the DE of lucerne was 9.3 kJ g^{-1}, but it was inferior for 7.66 kJ (diet with 99% lucerne). 9.3 kJ g DM^{-1} is the approximate minimum value established for a diet so that the energy intake is not limited.

While the level of crude protein of lucerne may be sufficient to cover the rabbit's requirements, nevertheless its digestible crude protein (DCP), often lower than the usual estimated requirements of 12-13%, does not seem to be suitable for a high growth rate. The aminoacid composition shows some deficiency in methionine, arginine and histidine. Finally, lucerne has little phosphorus and sodium, but it contains excess calcium.

Studies on the feeding of growing rabbits indicate that when lucerne is included in the diet up to a level of 40 % growth does not suffer (GIPPERT *et al.*, 1988); however 60% would cause a major reduction in growth according to CHEEKE and AMBERG (1972) but not according to HARRIS *et al.* (1981) who found comparable growth up to a lucerne level of 86%.

Therefore, the aim of the present work was to determine the performance of growing rabbits on lucerne considering that some of the obvious imbalances in energy, aminoacids and minerals can be partially corrected. In this experiment we have tried to evaluate a diet with 96% of lucerne, adding some of the nutrients cited above. Economic considerations, which may be easily deduced from local prices of feedstuffs, have not been considered.

MATERIAL AND METHODS

Diets.

Sun-cured commercial, pelleted lucerne was used, after milling with a 3 mm sieve. Diets were manufactured having the ingredients and composition shown in Table 1. Diet 1 was similar to a commercial diet; diet 2 had 96% of lucerne and diet 3 was diet 2 with the substitution of 8 % of lucerne by animal fat. To avoid excess calcium, instead the more usual calcium diphosphate, disodium phosphate was added to diets 2 and 3.

Chemical analyses of diets were conducted according to the methods of AOAC (1984) and VAN SOEST *et al.* (1991) for ADF. Gross energy was determined in an adiabatic bomb calorimeter.

Conclusions drawn from the results of the present experiment have to be related to the particular characteristics of the lucerne used, which could be said to have average quality. The response to other lucernes might have been significantly different.

Table 1 : Ingredients and composition of diets (%DM)

	Diets		
	1	2	3
Ingredients			
Lucerne hay	49	96	88.1
Barley	35		
Soya 44%	12		
Animal fat	1	1	8.9
DL-Methionine	0.1	0.1	0.1
Lysine		0.1	0.1
Arginine		0.2	0.2
Calcium diphosphate	2.3		
Disodium phosphate		2.1	2.1
Sodium chloride	0.3	0.2	0.2
Magnesiun sulphate		0.01	0.01
Vitamin/mineral supplement	0.2	0.2	0.2
Composition			
Crude protein	18.1	17.1	15.6
ADF	19.7	34.4	32.2
EE	4.0	4.2	11.1
Ash	9.5	13.2	12.0

Digestibility

Apparent digestibility of the diets was measured with 30 growing rabbits, six weeks old, in individual metabolism cages. Their faeces and urine were collected individually for 5 days after a 7-day adaptation period, following the standard procedure (PEREZ *et al.*, 1995).

Growth

The experiment was carried out in a traditional building with 35 day-old weaning animals. 289 rabbits (163 males and 126 females), previously fed on a commercial diet, were randomly assigned at weaning to each diet. Food intake and liveweight were individually recorded during the period between 35 and 70 days. Daily intake was always expressed in terms of the mean metabolic weight, in g DM or kJ DE. The experiment took place between November and April, and the average weekly minimum dry bulb temperature ranged from 12 to 19° C.

Carcass

Rabbits were fed *ad libitum* until transport to the slaughter - house in the morning, where the carcasses were obtained after removal of blood, skin, distal portions of legs, urine bladder, digestive tract and organs located in the thorax and neck. The weight of the full gastrointestinal gut was measured immediately after slaughtering, but internal organs were examined about six hours later, which could involve some little error. 181 carcasses were evaluated (100 from males and 81 from females)

The length of the carcass (DL, distance between the atlas and the 7th lumbar vertebra; Thigh length TL, distance between the 7th lumbar vertebra and the distal part of os ischii) and the lumbar circumference at the level of the 7th lumbar vertebra (LCL), were measured according BLASCO *et al.* (1993). Length of small intestine and length of colon were also measured. The stomach and caecum were weighted separately with and without their contents. Caecum volume was determined by submerging it in a graduated cylinder of water.

Table 2 : Apparent digestibility and nitrogen balance of diets

		Diets			
	n	1	2	3	SE
Dry matter digestibility, %	28	66_b	53_a	54_a	0.5
Organic matter digestibility, %	25	67.3_b	54.5_a	55.0_a	36.0
Crude protein digestibility, %	25	71.9_b	64.5_a	66.0_a	0.40
Digestible energy, kJ*(g DM)$^{-1}$	26	11.43_c	8.96_a	10.11_b	0.080
Nitrogen balance, g*day^{-1}	27	1.50_a	1.15_b	1.13_b	0.068
Apparent Metabolizable Energy (AME)[1], kJ*(g DM)$^{-1}$	23	10.94_c	8.50_a	9.66_b	0.086
Corrected Apparent Metabolizable Energy[2], kJ*(g DM)$^{-1}$		10.2	7.80	9.12	

[1] AME = DE-56*Urine*Urine N*DMI^{-1} kJ*(g DM)$^{-1}$, where DE is in kJ*(g DM)$^{-1}$, Urine in ml*day^{-1}, Urine N in g*ml^{-1} and dry matter intake (DMI) in g DM*day^{-1} (56 is combustion value of urine kJ*gN^{-1}, from SAMPELAYO *et al.*,1987; GRANDI and BATTAGLINI, 1987)

[2] Corrected AME = AME-56*NB*DMI^{-1} is AME corrected to zero nitrogen balance

Means within a row with different letters are significantly different at $P<0.05$

Table 3 : Effect of diet on growth parameters (LSM)

	SE	Diet 1	Diet 2	Diet 3
Animals at 35 d, no.		*96*	*95*	*98*
Liveweight, g				
35 d	4	857	857	844
70 d[1]	11	2290_b	2160_a	2150_a
Liveweight gain[1], g*d^{-1}	0.04	40.3_b	37.3_a	37.2_a
DM intake[1], g*kg$^{0.75}$*d^{-1}	0.5	79_a	101_c	90_b
DE intake[1], kJ*kg$^{0.75}$*d^{-1}	4.1	897	902	908
Feed conversion[1], gDM*g^{-1}	0.02	2.78_a	3.69_c	3.32_b
Mortality[2], %		18.7_b	8.4_a	5.1_a

LSM, Least-square mean; SE, standard error of mean; d, day. Covariate : [1] weight at 35 days; [2] Chi-square test. Means within a row with different letters are significantly different at P<0.05

Colour of the perirenal fat was measured with a CR 300 Minolta Chromameter (Minolta Camera Co., Osaka, Japan) which gives the L, a and b parameters (COMMISSION INTERNATIONAL DE L'ECLAIRAGE, 1976) as the average of three measurements at each point.

Statistical analysis.

Digestibility trial: Standard variance analysis was used on the data with diet (1, 2 and 3) as independent variable.

Growth and carcass: Standard variance analysis was used on the data, with diet (1, 2 and 3) and sex (male and female) as independent variables, considering as a covariate weaning weight for liveweight gain, intake and food efficiency; slaughtering weight for carcass weight and full gastrointestinal tract for parts of the tract. Scheffe test was used for comparisons between single means. A Chi-square test was performed to estimate the frequencies associated with mortality rate.

RESULTS

Digestibility

The values of digestibility and nitrogen balance for diet 1 were better than those for diets 2 and 3 (Table 2). The DE level of this diet was greater than that of diet 2. The energy value deduction corresponding to urine resulted in ME values which followed the same pattern as that mentioned for DE (1>3>2).

The individual DE values of lucerne and fat, assuming no interaction between these two fractions and a digestibility value of 100 for the aminoacids, can be deduced from the equations:

100 g diet 2: 896 kJ= 96.0*lucerne + 1.0*fat + 0.4*24
100 g diet 3: 1011 kJ= 88.1*lucerne + 8.9*fat + 0.4*24

from which, DE of lucerne and fat are 9.06 and 23.84 kJ (g DM)$^{-1}$ respectively.

Growth

A summary of the results obtained for the three diets is shown in Table 3. Food conversion ratio was 3.26 for males and 3.18 for females (P<0.05). Except for this, neither sex nor sex*diet interaction affected any of the growth parameters considered, and for this reason these data are not presented in Table 3.

Most variables were significantly affected by diet. Liveweight of rabbits of 70 days and daily liveweight gain were higher (P<0.001) for rabbits on Diet 1, and similar for those on Diets 2 and 3.

Dry matter intake was inversely related to the DE content of the diets (P<0.001). Those differences in DM intake gave similar ingestion in DE for the three diets. Feed conversion for diet 2 was the poorest, as a consequence of both high DM intake and low liveweight gain.

Mean mortality rate was about 11%. The Chi-square analysis revealed a higher significant mortality (P<0.001) for diet 1 compared with diets 2 and 3.

Carcass

The covariate, when introduced, always significantly affected results, except for weight of the empty stomach.

Sex affected only weight of gastrointestinal tract, the values being higher for females than for males: 20.7 *vs* 19.7 (P<0.05). No significant interaction between sex and diet were found. Consequently only the results for the carcasses and internal organs for the three diets are presented in Table 4.

Diet affected many of the variables that are related to both carcass and digestive organs. Those ascribed to the carcass itself such as weight of carcass and dressing percentage were significantly higher for diets 1 and 3 (P<0.001).

Some parts of the digestive tract had lower weight (P<0.01) for diet 1 (empty stomach and stomach contents), others varied for diet 3 (caecum volume and contents) and colon length was a little longer (P<0.05) for diet 2 than for diet 1. The lumbar circumference was smaller but the commercial carcass was longer in rabbits fed on diet 2.

Other measurements connected to fat content of the carcass are given in Table 5. The overall results showed that diet significantly affected the content and colour of dissectible fat. However sex also affected fat, especially the amount of perirenal fat (P<0.001). The respective results showed that a little more inguinal fat (12.1 g *vs* 11.2 g, P<0.1) and rather more perirenal fat (17.9 g *vs* 15.6 g, P<0.001) was found in females than in males.

Table 4 : Effect of diet on carcass traits (LSM)

	SE	Diet 1	Diet 2	Diet 3
Animals, no.		*55*	*61*	*65*
Live weight (LW), g	140	2270_a	2190_a	2160_{ab}
Blood weight, %LW	0.15	5.4	5.7	5.2
Skin weight, %LW	0.06	11.5_b	11.1_a	11.3_{ab}
Full Gastrointestinal Tract, %LW	0.20	18.9_a	21.3_b	20.3_b
Hot Carcass[1], g	3.2	1310_b	1260_a	1300_b
Cold Carcass[1], g	3.2	1270_b	1220_a	1260_b
Dressing Percentage, %	0.15	57.8_b	55.4_a	57.2_b
Dorsal length DL[2], cm	0.06	25.3_a	26.1_c	25.8_b
Thigh length TL[2], cm	0.03	8.2	8.3	8.2
Lumbar circ. LCL[2], cm	0.05	17.3_{ab}	17.0_a	17.4_b
Liver[2], g	1.01	89.6_b	89.3_a	83.1_a
Kidneys[2], g	0.12	14.9_a	17.5_c	16.3_b
Stomach[3], g	0.17	15.6_a	17.7_b	17.2_b
Stomach contents[3], g	1.53	49.8_a	73.2_c	63.0_b
Small Intestine[3], cm	2.8	385	378	377
Caecum[3], ml	2.20	185_b	184_b	172_a
Caecum[3], g	0.26	23.7	24.4	23.2
Caecum contents[3], g	1.5	148_b	148_b	135_a
Caecum contents, %DM	0.18	20.4_b	19.2_a	20.1_{ab}
Caecum contents, pH	0.03	6.19	6.16	6.22
Colon[3], cm	0.17	35.8_a	37.0_b	36.1_{ab}

LSM, Least-square mean; SE, standard error of mean. Covariate:[1]Liveweight; [2]Cold carcass; [3]Full gastro-intestinal tract. Means within a row with different letters are significantly different at P<0.05

The only significant sex*diet interaction (P<0.01) was found for scapular fat: more fat was found in females on diet 3, while the amounts were similar for both sexes on diets 1 and 2.

DISCUSSION

Digestibility

The values of DE for lucerne with about 32% ADF, given by FERNANDEZ *et al.* (1996) ranged between 8.8 and 9.1 kJ/g DM. Applying the regression equation published by these authors to diet 2, DE is 9.03, the same value as found in the trial. Obviously diet 3 had a higher DE content than diet 2, the difference being due to the animal fat added.

The calculated values of apparent metabolizable energy (AME) were very near to 95% DE, which are those found in the literature. When corrected to zero nitrogen balance they fall to 91%.

Higher CP digestibility of diet 1 was a consequence of inclusion of some protein from soya meal and barley. Digestible values for protein were within the normal range and similar for diets 2 and 3, which means that fat addition did not affect protein digestibility; In this frequently-debated matter, the results published are contradictory. The digestibility of lucerne protein, calculated from diet 2, was 63%, a normal value. Higher values reported by LEBAS (1987) involved industrially-dehydrated lucerne.

Growth

Diet 1 yielded better gains and efficiency than diets based on alfalfa. The nitrogen balance indicates a smaller retention of nitrogen on diets 2 and 3, suggesting a daily weight gain for these rabbits of 1.15*6.25/0.2=36 g, quite close to the actual gains shown in Table 3.

As expected, rabbits could not compensate for the low energy content of alfalfa diets and their growth was impaired, although food intake, especially on diet 2, increased substantially. The apparent incompatibility between a similar energy intake and different gains when diet 1 and alfalfa diets are compared can be explained if the DE value of fibrous diets is overestimated, as some other works have recently suggested (ORTIZ *et al.*, 1989).

Similar gains of rabbits on diets 2 and 3 were linked to similar DE intakes. This response has been usually found when, as was the case, the decrease in DM ingestion did not compensate for the higher DE of the fat-diets. The higher energy efficiency of diet 3 would cause a higher energy retention in the carcass, which is in fact reported below.

Diet 3 had a higher DE/DCP ratio than diet 2 (98 and 82 $kJ*g^{-1}$ respectively). Daily digestible protein intake was 12.5 g in rabbits fed on diet 3, perhaps below the optimal requirements, and consequently growth might be improved by addition of a protein or aminoacid supplement. The same idea was brought out by the experiment of CERVERA *et al.* (1997) where a

Table 5 : Effect of diet on dissectible fat (LSM)

	SE	Diet 1	Diet 2	Diet 3
Animals, no.		*55*	*60*	*62*
Scapular fat[1], g	0.11	6.0_b	4.5_a	7.5_c
Inguinal fat[1], g	0.26	11.6_b	8.7_a	14.5_c
Perirenal fat[1], g	0.38	15.6_b	11.4_a	23.1_c
Colour diagram:				
Brightness L	0.17	69.3	69.9	69.5
Red tone a	0.13	6.5_a	6.0_a	3.9_b
Yellow tone b	0.09	5.5_a	5.6_a	4.1_b

LSM, Least-square mean; SE, standard error of mean. Covariate : [1] Cold carcass. Means within a row with different letters are significantly different at P<0.05

diet formulated to have 8.5% of animal fat was used in fattening rabbits at a high ambient temperature.

The feed conversion ratio of the lucerne-based diet was substantially improved when fat was added, but continued to be about 0.5 units worse than that corresponding to diet 1. This point has to be taken into account together with the dressing out percentage which appears in Table 4, meaning that there was a substantial increase in feed per kg of carcass produced.

Mortality has often been related to fibrous diets for weaned animals and minimal fibre is usually recommended for fattening animals. HARRIS *et al.* (1981) registered a mortality rate of 26.6, 12.7 and 8.5, when rabbits were fed on diets with levels of 28, 54 and 74 lucerne respectively. It is likely that the effect of increasing the proportion of lucerne in a diet would be greater when the mortality rate is high. In our case, the mortality rate observed with diet 1 was rather high, and consequently lucerne diets may turn out to be suitable only in these circumstances.

Carcass.

The gastrointestinal tract was heavier in females and this could be related to the different degree of maturity of the two sexes (LOPEZ *et al.*, 1988), besides that the gastrointestinal tract measurement includes the reproductive organs. KERMAUNER and STRUKLEC (1996) also reported higher weight of caecum and small intestine in female rabbits.

Adaptation to high fibrous diets increases size of the digestive system: length of intestine, length of caecum and weight of caecum in chicks (JORGENSEN *et al.*, 1996a), caecum and colon in rats (ZHAO *et al.*, 1996) and weights of stomach, caecum and colon length in pigs (JORGENSEN *et al.*, 1996b). The effect of lucerne hay on rabbits was examined by GARCIA *et al.* (1995b), showing greater caecum contents and complete digestive tract weight when the NDF content of diets was increased. LEBAS *et al.* (1982) reported that an increased dietary fibre caused a corresponding increment of caecum content alone.

Nevertheless, most works reporting that effect of sex or diet, and certainly these previously cited, are not strictly comparable to our results because they use absolute values for these parameters: they do not take into account the relative value for the entire gastrointestinal tract, which is not considered to be fixed or used as a covariate.

The weight of the stomach contents was closely related to dry matter intake, although any single measurement of gut contents is always a matter for discussion. A high fat level would cause a low fermentation rate in the caecum, which could be related to the lower material retention and volume of the caecum itself found in rabbits fed on diet 3. Both lower stomach and caecum contents should increase the dressing percentage of the carcass.

Dressing yield of rabbits fed on the control diet was similar to that found in other experiments with rabbits of 2 kg-weight which is about 60%. It was lower for diet 2, and similar for the control and fat diets.

A higher dressing out percentage has often been observed in correlation with higher energy content in the diet, which usually corresponds with a lower fibre content (MAERTENS *et al.* 1989; BUTCHER *et al.*, 1981). Conversely an increase in digestible fibre content, in either amount or quality, consistently leads to decreased dressing out percentage in rabbits (LEBAS, 1975; PEREZ DE AYALA *et al.*, 1991). Using liveweight as a covariate, dressing weight is most affected by the weight of the gastrointestinal tract and diet 2 gave the lowest figure. The fat content in diet 3 should counterbalance the disadvantageous effect of fibre, in agreement with PLA and CERVERA (1997) who have found higher carcass weight in rabbits fed on a 9.9 EE % diet.

Liver represented 7% of the carcass weight, closely coincident with the figure obtained by LEBAS *et al.* (1982) and similar to those of other authors. Earlier reports on liver weight variation with diet were not conclusive (OUHAYOUN *et al.*, 1986). SCHLOLAUT *et al.* (1984) found that liver was heavier in rabbits fed on a fibre rich diet. Heavier livers have been found in rabbits fed on a high energy diet, of estimated DE 13.1 kJ (g DM)$^{-1}$ (BUTCHER *et al.*, 1981) and lighter ones were reported by LEBAS *et al.* (1982) with a diet of 9.6 kJ (g DM)$^{-1}$. Liver was heavier on the control diet, decreasing with fat addition, in the work of FERNANDEZ and FRAGA (1996).

The lumbar circumference includes the volume of fat contained in the abdominal cavity, so it was smaller with diet 2. Carcasses take a more compact shape when the circumference increases. FERNANDEZ and FRAGA (1996) reported that of the three measurements of length made on the carcasses only lumbar circumference increased with addition of fat.

Deposition of fat is a variable very sensitive to variation of diet. RAIMONDI *et al.* (1974), PARTRIDGE *et al.* (1986), OUHAYOUN *et al.* (1986) and FERNANDEZ and FRAGA (1996) all reported increases in perirenal fat when fat was added to diets. Females tended to have more fat than males. Considering the scapular fat where the difference between sexes was not significant, females on diet 3 were fatter, and that result was the origin of the sex*diet interaction referred to above. In fact, females on a fat diet seem better able to take advantage of this diet, as they have much fatter carcasses.

Colour measured on the perirenal fat was only affected by the fat. Diet 3 had the palest fat, probably related to the origin of this fat, whether deposited or synthesized. PLA and CERVERA (1997) also found that fat from rabbits fed on diets with vegetable or animal fat added was less coloured.

CONCLUSION

The diet with 96% of lucerne could support a fairly good rate in weaned rabbits and the addition of fat increased dressing out percentage and dissectible fat of carcasses, although no difference in growth rate was detected. Lucerne diets were related to a substantial decrease of mortality rate, which was originally high.

Acknowledgement : The present work was supported by a grant from CICYT (AGF97-1139)

Received : October 24th, 1997
Accepted : February 6th, 1998

REFERENCES

AOAC, 1984. Official Methods of Analysis (14th ed.). *Association of Official Analytical Chemists, Washington, DC.*

BLASCO A., OUHAYOUN J., MASOERO G., 1993. Harmonization of criteria and terminology in rabbit meat research. *World Rabbit Sci., 1(1), 3-10.*

BUTCHER C., BRYANT M.J., MACHIN D.H., OWEN E., OWEN J.E., 1981. The effect of metabolizable energy concentration on performance and digestibility in growing rabbits. *Tropical Anim. Prod., 6, 93-100.*

CERVERA C., BLAS E., FERNANDEZ-CARMONA J., 1997. Growth of rabbits under different environmental temperatures using high fat diets. *World Rabbit Sci., 5, 71-76.*

CHEEKE P.R., AMBERG J.W., 1972. Protein nutrition of the rabbit. *Nutrition Reports Inter., 5, 259-266.*

COMMISSION INTERNATIONAL DE L'ECLAIRAGE, 1976. CIELAB metodica. *Publication no. 36.* Paris

FERNANDEZ C., FRAGA M.J., 1996. The effect of dietary fat inclusion on growth, carcass characteristics and chemical composition of rabbits. *J. Anim. Sci., 74, 2088-2094.*

FERNANDEZ-CARMONA J., CERVERA C., BLAS E., 1996. Prediction of the energy value of rabbits feeds varying widely in fibre content. *Anim. Feeding Sci. Tech., 64, 61-75.*

GARCIA J., DE BLAS J.C., CARABAÑO R., GARCIA P., 1995b. Effect of type of lucerne on caecal fermentation and nitrogen contribution trough caecotrophy in rabbits. *Reprod. Nutr. development, 35, 267-275.*

GARCIA J., PEREZ-ALBA L., ALVAREZ C., ROCHA R., RAMOS M., DE BLAS J.C., 1995a. Prediction of the nutritive value of lucerne hay in diets for growing rabbits. *Anim. Feed Sci. Tech., 54, 33-44.*

GIPPERT T., HULLAR I., SZABO S., 1988. Nutritive value of agricultural by-products in rabbit. In: *Proc. of the 4th World Rabbit Congress, Budapest, Vol 3, 154-162.*

GRANDI A., BATTAGLINI M., 1987. Valutazione dell'energia metabolizzabile nel coniglio. *Rivista di Coniglicoltura, 24 (10), 49-51.*

HARRIS D.J., CHEEKE P.R., PATTON N.M., 1981. Utilization of high alfalfa diets by rabbits. *J. Appl. Rabbit Res., 4, 30-34. In: VI Journées de la Recherche Cunicole, La Rochelle Vol 2, 355-364.*

JORGENSEN H., ZHAO X.Q., EGGUM-BO, 1996b. The influence of dietary fibre source and environmental temperature on the development of the gastrointestinal tract, digestibility, degree of fermentation in the hind-gut and energy metabolism in pigs. *British J. Nutr., 75(3), 365-378.*

JORGENSEN H., ZHAO X.Q., KNUDSEN-KEB, EGGUM-BO, 1996a. influence of dietary fibre source and level on development of the gastrointestinal tract, digestibility and energy metabolism in broiler chickens. *British J. Nutr., 75(3), 379-395.*

KERMAUNER A., STRUKLEC M., 1996. Addition of probiotic to feeds with different energy and ADF content in rabbits. I. Effect on the digestive organs. *World Rabbit Sci., 4, 187-193.*

LEBAS F., 1975. Influence de la teneur en energy de l'aliment sur les performances de croissance chez le lapin. *Ann. Zootech., 24, 281-288.*

LEBAS F., 1987. La luzerne déshydratée et le lapin. *Cuni- Sciences, 4(1), 11-22.*

LEBAS F., LAPLACE J.P., DROUMENQ P., 1982. Effets de la teneur en énergie de l'aliment chez le lapin. Variations en fonction de l'âge des animaux et de la séquence des régimes alimentaires. *An. Zootech. , 31, 233-256.*

LOPEZ A., DELTORO J., CAMACHO J., 1988. Quantitative growth of rabbit organs. In: *Proc. of the 4th World Rabbit Congress., Vol II, 352-360.*

MAERTENS L., BERNAERTS D., DECUYPERE E., 1989. L'energie et l'aliment en engraissement. *Cuniculture, 16(4), 189-194.*

MAERTENS L., DE GROOTE G., 1981. L'energie digestible de la farine de luzerne déterminée par de essais de digestibilité avec des lapins de chair. *Revue de l'Agriculture, Vol 1, 34, 79-92.*

ORTIZ V., DE BLAS J.C., SANZ E., 1989. Effect of dietary fiber and fat content on energy balance in fattening rabbits. *J. Appl. Rabbit Res., 12, 159-162.*

OUHAYOUN J., LEBAS F., DELMAS D., 1986. La croissance et la composition corporalle du lapin: Influence des facteurs alimentaires. *Cuni-Sciences, 3, 7-21.*

PARTRIDGE G.G., FINDLAY M., FORDYCE R.A., 1986. Fat supplementation of diets for growing rabbits. *Ani. Feed Sci. Technol., 16, 109-117.*

PEREZ DE AYALA P., FRAGA M.J., CARABAÑO R., DE BLAS J.C., 1991. Effect of fibre source on diet digestibility and growth in fattening rabbits. *J. Appl. Rabbit Res., 14, 159-165.*

PEREZ J.M., 1994. Digestibilité et valeur énergetique des luzernes deshydrateés pour le lapin : Influence de leur composition chimique et de leur technologie de préparation. *6èmes Journéees de la Recherche Cunicole, La Rochelle, 355-364.*

PEREZ J.M., LEBAS F., GIDENNE T., MAERTENS L., XICCATO G., PARIGI-BINI R., DALLA-ZOTTE A., COSSU M.E., CARAZZOLO A., VILLAMIDE M.J., CARABAÑO R., FRAGA M.J., RAMOS M.A., CERVERA C., BLAS E., FERNANDEZ-CARMONA J., FALCAO E CUNHA M.L., BENGALA FREIRE J., 1995. European reference method for in vivo determination of diet digestibility in rabbits. *World Rabbit Sci., 3, 41-43.*

PLA M., CERVERA C., 1997. Carcass and meat quality of rabbits fed with diets having a high level of vegetable or animal fat. *Anim. Sci.* (in press).

RAIMONDI R., AUXILIA MT., DE MARIA C.,MASOERO G., 1974. Effect of dietary fat on production of meat rabbit. 1. growth, food consumption and killing out percentage. *An. Istituto Sperimentale per la Zootecnia, 7, 217-235.*

SAMPELAYO R.S., FONOLLA J., ESCANDON V., 1987. Relaciones existentes entre energía, nitrógeno y materia seca de la orina. Estudio comparativo en corderos y conejos. *Archivos de Zootecnia,* 36, *134, 37-43.*

SCHOLAUT W., WALTER A., LANGE K., 1984. fattening performance and carcass quality in the rabbit in dependence on the final fattening weight and the fattening method. In: *Proc. of the 3rd World Rabbit Congress,. Vol 1, 445-452.*

VAN SOEST P.J., ROBERTSON J.B., LEWIS B.A., 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. *J. Dairy Sci., 74, 3583-3597.*

ZHAO X.Q., JORGENSEN H., GAVERT V.M., 1996. Effect of environmental temperature on digestive tract, visceral organ size, digestibility and energy metabolism in rats fed different levels of pea fibre. *Acta Agriculturae Scandinavica, section A, Animal Science, 46, 183-192..*