WORLD RABBIT SCIENCE 1996, 4 (4), 187-193

ADDITION OF PROBIOTIC TO FEEDS WITH DIFFERENT ENERGY AND ADF CONTENT IN RABBITS.

1. EFFECT ON THE DIGESTIVE ORGANS

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ABSTRACT : Effects of feed composition, addition of the probiotic Acid-Pak 4-Way (AP4W), sex, age at slaughtering (53 or 67 d.) and interactions between feed and AP4W, age and feed, age and AP4W and age and sex on gastrointestinal (GI) tract weight and dressing percentage of 84 weaned New Zealand White rabbits were studied. Three complete feed mixtures with different levels of digestible energy (DE, MJ/kg of feed) and ADF content (g/kg of dry matter-DM) were tested (feed I had recommended DE and high ADF content: 9.22 MJ DE and 299 g ADF; feed II had 11.60 MJ DE and 254 g ADF; feed III had high energy and recommended ADF content: 13.14 MJ DE and 187 g ADF), each with and without the addition of 0.5 % AP4W. High-energy/recommended-ADF diet (feed III) increased carcass weight (I : 970^a ; II : 976^a ; III : 1005^bg; P≤0.05), improved dressing percentage (I : 50.2^a, II : 50.6^a , III : 52.0^b %, P≤0.05), decreased GI weight (I : 411.1^{ab}, II : 420.2^a, III : 391.3^b g, P≤0.05) and decreased caecum weight (I 151.3^a, II 148.8^a, III 133.7^b g, P≤0.05). The proportions of small intestine and caecum (of total GI weight) differed between feed I and III (% of small int.: 20.2 *vs.* 22.3; % of caecum: 36.9 *vs.* 34.0, P≤0.05). The effect of AP4W was observed only in the decreased proportion of stomach and increased proportion of caecum (% of stomach: 28.0 *vs.* 29.9, % of caecum: 36.2 *vs.* 34.8 %, (P≤ 0.05). Sex significantly (P≤0.05) influenced caecum weight (females: 151.1, males 138.2 g), % of caecum (f. 36.6, m. 34.4 %) and % of small intestine (f. 20.7, m. 21.7 %). Older rabbits had (P≤0.05) better dressing percentage (52.0 *vs.* 49.9 %), higher carcass weight (1007 *vs.* 961 g), lower GI tract (392.7 *vs.* 422.4 g) and small intestine weight (80.0 *vs.* 92.1 g), higher weight and % of large intestine (63.0 *vs.* 54.8 g, 14.9 *vs.* 13.8 %).

RÉSUMÉ : Etude chez le lapin de l'addition d'un probiotique à des aliments composés à niveaux énergétiques et d'ADF différents. 1 - Influence sur les organes digestifs.
Avec 84 lapins Néo Zélandais Blancs sevrés à 32 jours, ont été étudiés les effets, sur le poids du tractus gastrointestinal et le rendement à l'abattage, de la composition de l'aliment, de l'addition d'un probiotique Acid-Pak 4-Way (AP4W), du sexe, de l'âge à l'abattage (53 ou 67 jours) et les interactions entre l'aliment et l'addition de AP4W, l'âge et l'aliment, l'âge et AP4W et l'âge et le sexe. Trois aliments complets à niveaux d'énergie digestible (ED, MJ/kg) et contenu en ADF (g/kg MS) différents ont été testés (aliment I : 9.22 MJ ED et 299g ADF ; aliment II : 11.6 MJ ED et 254g ADF ; aliment III : 13.14MJ ED et 187g ADF), chacun d'entre eux étant doublé par le même aliment additionné de 0.5% d'AP4W. L'aliment III haute énergie & taux d'ADF le plus bas augmente le poids de carcasse (I : 970^a ; II : 976^a ; III : 1005^bg ; P≤0.05), améliore de rendement à l'abattage (I : 50.2^a ; II : 50.6^a ; III : 52.0^b %, P≤0.05), diminue le poids du tractus gastrointestinal (I : 411.1^{ab}, II : 420.2^a, III : 391.3^b g, P≤0.05) et diminue le poids du caecum (I : 151.3^a ; II : 148.8^a ; III : 133.7^b g, P≤0.05). Les proportions de l'intestin grêle et du caecum diffèrent avec les aliments I et III (% d'intestin grêle : 20.2 vs 22.3 ; % de caecum : 36.9 vs 34.0, P≤0.05). On observe un effet d'AP4W entraînant la diminution de la proportion de l'estomac et l'augmentation de la proportion du caecum (% de l'estomac : 28.0 vs 29.9 ; % du caecum : 36.2 vs 34.8, P≤0.05). Le sexe influence significativement (P≤0.05) le poids du caecum (femelle : 151.1; males : 138.2 g) le pourcentage du caecum (f. : 36.6 ; m. : 34.4 %) et le pourcentage d'intestin grêle (f. : 20.7 ; m. : 21.7 %). Les lapins les plus âgés ont un meilleur rendement à l'abattage (P≤0.05) (52.2 vs 49.9 %), des carcasses plus lourdes (1007 vs 961 g) une diminution du poids tractus gastrointestinal (392.7 vs 422.4 g) et de l'intestin grêle (80.0 vs 92.1 g) et un gros intestin plus lourd et proportionnellement plus important (63.0 vs 54.8 g, 14.9 vs 13.8 %).

INTRODUCTION

Energy and fibre contents are important variables when compounding feed mixtures for rabbits. High daily weight gains and optimum feed efficiency are the main objectives during the fattening period, and therefore feed rich in energy should be used.

A high energy level in feed can be achieved by a high proportion of cereal grains. Such feed may cause a starch overload in the caecum which results in altered microbial fermentation. Consequently, potentially pathogen microorganisms may develop, leading to enteritis (CHEEKE and PATTON, 1980) which is one of the main reasons for mortality of fattening rabbits, causing serious economic loss. High energy feeds often have low fibre content, which also has a negative effect on digesta transit time, retention time and turnover rate of caecal digesta (CHEEKE, 1987; GIDENNE, 1992), all contributing to the appearance of enteritis (LAPLACE, 1978).

De BLAS *et al.* (1986) suggested that in order to study diets implying risks of digestive disorders, the weight of the caecum content (or the total caecum weight) could be a more objective measurement than the highly variable mortality rate. They noticed a connection between higher caecum weight and mortality.

Many authors reported relationship between fibre content in feed and GI tract weight. When feed with very low fibre content (under recommended values) was used, a higher empty caecum weight (DEHALLE, 1981) and a higher total caecum weight (de BLAS *et al.*, 1986) were reported. A lower content of indigestible fibre (beet root pulp instead of dried alfalfa) increased caecum volume and weight (CANDAU *et al.*, 1979); GARCIA *et al.* (1993) observed an increased gut content weight when sugar beet pulp was fed instead of barley. In contrast LEBAS *et al.* (1982), GIDENNE (1992) and GARCIA *et al.* (1994) reported a higher caecum weight when rabbits were fed with high fibre diets. This results confirm the inconvenience of feed mixtures either with too low or too high fibre content (LEBAS, 1991): low fiber content negatively influences digesta transit time and high fibre content leads to an increased ammonia concentration in caecum due to extended rate between protein and energy; the consequence of both is proliferation of potentially pathogen microorganisms in caecum.

Table 1 : Composition, chemical analysis and calculated DE content of experimental feed mixtures

	Feed Mixture					
Component %	**I**	**I+[a]**	**II**	**II+[a]**	**III**	**III+[a]**
Alfalfa meal	42.0		30.7		14.7	
Sugar beet pulp	10.0		20.0		25.0	
Barley	5.0		3.0		15.0	
Oats	-		5.0		5.0	
Wheat middling	5.0		6.6		8.7	
Soya meal	7.0		5.5		6.0	
Sunflower meal	10.0		10.0		7.55	
Pumpkin cake	2.0		2.0		4.5	
Brewer's yeast	-		2.0		2.0	
Oil	0.2		4.0		5.0	
Sawdust	12.5		5.0		-	
Molasses	0.5		0.3		0.3	
Binder	1.0		1.0		1.0	
Premix	1.0		1.0		1.0	
Mineral mix	3.5		3.6		3.95	
Lysin	0.3		0.3		0.3	
Acid-Pak 4-Way	-	*0.5*	-	*0.5*	-	*0.5*
Dry matter (g/kg)	881.5		903.3		903.4	
Crude protein (g/kg DM)	201.6		198.3		204.9	
Crude fibre (g/kg DM)	262.8		230.5		155.0	
NDF (g/kg DM)	426.1		387.0		328.4	
ADF (g/kg DM)	299.4		254.0		186.9	
ADL (g/kg DM)	91.1		64.9		51.4	
DE (MJ/kg feed)[b]	9.22		11.60		13.14	

[a] feed with + is feed with addition of 0.5 % AP4W ; [b] calculated from tables (SCHLOLAUT, 1982)

Findings of recent studies (YAMANI *et al.*, 1992; GIPPERT *et al.* 1992; EL-HINDAWY *et al.*, 1993) indicate that the digestive process and consequently production and slaughter traits may be favorably affected by different feed additives such as probiotics. Probiotics are simple or combined products; the latter are composed of bacteria or yeast cultures, different organic acids or sometimes certain enzymes. Such probiotic feed additives are especially efficient in certain stress conditions (LYONS, 1987; FOX, 1988, MAERTENS and DE GROOTE, 1992), being even more interesting in intensive rabbit breeding management systems. The use of probiotics and similar additives together with adequate ration composition might be a tool for overcoming digestive difficulties that occur due to the unbalanced feed quantity and composition in relation to nutritional and physiological needs of growing rabbits.

The first aim of our study was to establish whether high energy feed can be fed to weaning rabbits without an increased risk of digestive disorders (measured by total caecum weight); and the second one, how different fibre concentrations in feed together with the addition of probiotic feed additive influenced the weights and proportions of GI organs in rabbits.

MATERIAL AND METHODS

A total of 84 New Zealand White rabbits, both female and male, weaned at the age of 32 days (795 g, SD = 110) were randomly allotted to 6 groups. Rabbits were housed individually in wire cages. After an adjustment period of one week, rabbits were given the trial feed *ad libitum*. Half of the animals in each group was slaughtered at the age of 53 days and the other half at the age of 67 days. Feed was withdrawn 2 hours before slaughtering at 10 a.m. In both age groups the following parameters were measured: live weight at slaughter, weight of warm carcass (excluding head and lower parts of legs), dressing percentage, weight of the whole GI tract as well as weight of separate parts of the GI tract including its content (stomach, small intestine, caecum and large intestine); the proportions of separate GI organs with respect to the total GI tract weight were finally calculated. Zootechnical parameters were measured as well (feed intake, weight gain, feed conversion ratio).

Three different feeds were tested in the experiment (feed I, II and III) each with and without the addition of 0.5 % probiotic Acid-Pak 4-Way (AP4W). Feed mixtures differed regarding digestible energy (DE) content and fibre (ADF) level. The content of proteins, minerals and vitamins did not differ (Table 1). Comparing to nutrient recommendations of MAERTENS (1995) all three trial feeds had high crude protein (CP) content. Feed I had DE close to recommendations, but high content of ADF; feed III had high DE content and ADF content close to recommendations of MAERTENS (1995). Probiotic AP4W (Alltech. Inc., U.S.A.) is an additive composed of microencapsulated lactobacillus (*Lactobacillus acidophilus, Streptococcus faecium*), enzymes (amylases, cellulases and proteases) from dried *Aspergillus niger* and *Bacillus subtilis* fermentation extracts, electrolytes (Na, K) and acids (citric and sorbic acid).

Data were subjected to statistical analysis using the GLM procedure in the SAS statistical program (SAS/STAT, 1990). Covariate analysis (regression on slaughter weight or feed intake) was included in model where it was shown to be significant. The model was:

$$y_{ijkl} = \mu + F_i + P_j + S_k + A_l + F.P_{ij} + A.F_{il} + A.P_{jl} + A.S_{kl} + b_1x + b_2x^2 + e_{ijkl}$$

y_{ijkl} - measured value
μ - population mean
F_i - effect of the feed (i = 1,2,3)
P_j - effect of the probiotic AP4W (j = 1,2)
S_k - effect of the sex (k = 1,2)
A_l - effect of the age (l = 1,2)
$F.P_{ij}$ - effect of the interaction between feed and AP4W (ij = 1,2,3,4,5,6)
$A.F_{il}$ - effect of the interaction between age and feed (il = 1,2,3,4,5,6)
$A.P_{jl}$ - effect of the interaction between age and AP4W (jl = 1,2,3,4)
$A.S_{kl}$ - effect of the interaction between age and sex (k_l = 1,2,3,4)
b_1, b_2 - regression coefficients
e_{ijkl} - error

Table 2 : Analysis of variance, significance (P) of all effects for parameters tested in rabbits

	Main effects				Effects of interactions				Regression		
Tested parameter	Feed	AP4W	Sex	Age	Feed* AP4W	Age* Feed	Age* AP4W	Age* Sex	covari-able	lin.	quad.
Carcass weight	**0.004**	0.445	0.832	**0.003**	**0.002**	0.644	0.345	0.353	Slaughter weight	**0.000**	-
Dressing percentage	**0.014**	0.508	0.946	**0.012**	**0.003**	0.442	0.352	0.480	Slaughter weight	**0.043**	-
GI tract weight	**0.033**	0.995	0.200	**0.051**	**0.003**	0.265	0.642	0.600	Slaughter weight	**0.000**	-
Stomach weight	0.125	0.294	0.621	0.135	0.551	**0.025**	0.911	0.775	Slaughter weight	**0.001**	-
Small intestine weight	0.524	0.520	0.681	**0.002**	**0.031**	0.482	0.665	0.857	Slaughter weight	**0.000**	-
Caecum weight	**0.001**	0.241	**0.002**	0.161	**0.001**	0.264	0.840	0.073	Slaughter weight	**0.001**	-
Large intestine weight	0.140	0.241	0.934	**0.000**	**0.016**	0.463	**0.089**	0.400	-		
% of stomach	0.641	**0.018**	0.311	0.328	0.233	**0.005**	0.343	0.643	Feed intake	**0.002**	**0.002**
% of small intestine	**0.006**	0.584	**0.041**	0.323	0.738	**0.091**	0.291	0.316	Feed intake	**0.009**	**0.003**
% of caecum	**0.001**	**0.031**	**0.001**	1.000	**0.093**	0.516	0.970	**0.060**	Slaughter weight	**0.003**	**0.005**
% of large intestine	0.494	0.144	0.462	**0.007**	0.451	0.152	0.252	0.215	Feed intake	**0.020**	**0.059**

RESULTS AND DISCUSSION

The significance (P) of all the effects is shown in an Anova table (Table 2). Mortality was low: one rabbit was eliminated due to scours (feed III) and one rabbit died (feed II+). As to zootechnical parameters, only the influence of feed composition was significant (Table 3). Rabbits fed with feed III had the highest final live weight, the lowest feed intake and the best feed conversion ratio.

1 Effect of feed

The influence of feed composition on the tested traits is shown in Table 4. The dressing percentage was the best when feed III (high-energy/recommended-ADF) was used, especially due to the increased carcass weight and decreased weight of the GI tract, including its content.

The GI tract weight and caecum weight were the lowest in group III. GARCIA *et al.* (1995) found the linear increase of GI tract, stomach, caecum and caecum content weight (expressed in % of body weight) with dietary NDF content on DM basis. In group III the proportion of caecum was the lowest and the proportion of small intestine was the highest (despite regression on feed intake). De BLAS *et al.* (1986) noticed a relation between a higher caecum weight and mortality: a high caecum weight means a higher risk for digestive disturbances because of higher digesta retention time in caecum. Despite the lower feed intake of feed III this group had the lowest weight of both GI tract and caecum in our trial. The ADF content in feed III was probably sufficient to assure a normal turnover rate of caecal digesta. GIDENNE (1993) found a reduced mean retention time when the level of ADF increased (from 159 to 221 g ADF/kg DM of feed; restricted feeding). But GIDENNE and PEREZ (1994) found that only the rate of passage of the largest particles was affected by ADL levels in diet.

GIDENNE (1992) found a lower caecum weight compared to our results (caecum+content: 114 - 138 g) at almost the same weight and the same age at slaughtering but he also found a similar influence of feed. LEBAS *et al.* (1982) reported similar caecum weights (including content), while the increased dietary fibre level caused an increased weight of caecum content alone. A similar effect of feed on caecum weight was observed by HOOVER and HEITMANN (1972), GIDENNE (1992) and GARCIA *et al.* (1994), while other authors reported an increased caecum weight only when feed with very low fibre content, below 90 g CF/kg of feed (de BLAS *et al.*, 1986; DEHALLE, 1981) or low lignin - highly digestible fibre (FRAGA *et al.*, 1991) was fed.

The effect of ADF on caecum weight in our trial is in accordance to reviewed literature. Group III had the lowest caecum weight, indicating lower risk of digestive disorders; this group had also the lowest GI tract weight and the highest dressing percentage. Therefore feed, rich in energy can be fed to weaning rabbits without the increased danger of digestive disturbances. Energy content can be higher than recommended by MAERTENS (1995) in the case ADF content of feed is sufficient (over 20

Table 3: Influence of feed mixtures on zootechnical parameters of rabbits

Parameter	Feed I[1)]LSM[2)] ± SE n = 14	Feed II[1)] LSM ± SE n = 10	Feed III[1)] LSM ± SE n = 11
Final live weight (g)	2090[a] ± *37*	2150[ab] ± *45*	2241[b] ± *42*
Average daily weight gain (g/day)	40.3[a] ± *1.4*	42.8[ab] ± *1.6*	44.8[b] ± *1.6*
Average feed intake (g/day)	148.8[a] ± *3.6*	137.4[b] ± *4.1*	124.4[c] ± *3.9*
Average feed conversion ratio	3.80[a] ± *0.1*	3.18[b] ± *0.1*	2.80[c] ± *0.09*

[1)] Feed regardless AP4W

[2)] LSM with different letters in the same row are significantly different (P≤0.05)

Table 4 : Influence of feed mixtures on the parameters tested in rabbits

Parameter	Feed I[1)] LSM[2)] ± SE n = 28	Feed II[1)] LSM ± SE n = 23	Feed III[1)] LSM ± SE n = 24
Carcass weight (g)	970^{a} ± *7*	976^{a} ± *8*	1005b ± *8*
Dressing percentage (%)	50.2^{a} ± *0.4*	50.6^{a} ± *0.5*	52.0b ± *0.4*
GI tract weight (g)	411.1^{ab} ± *7.1*	420.2^{a} ± *7.9*	391.3b ± *7.8*
Stomach weight (g)	116.5^{ab} ± *4.0*	125.0^{a} ± *4.4*	112.6b ± *4.4*
Small intestine weight (g)	86.3 ± *1.8*	87.5 ± *2.0*	84.4 ± *2.0*
Caecum weight (g)	151.3^{a} ± *3.2*	148.8^{a} ± *3.5*	133.7b ± *3.5*
Large intestine. weight (g)	56.5 ± *1.6*	59.0 ± *1.8*	61.2 ± *1.7*
Proportion of stomach (%)	28.4 ± *0.7*	29.4 ± *0.7*	29.0 ± *0.8*
Proportion of small intestine (%)	20.2^{a} ± *0.4*	21.2^{ab} ± *0.4*	22.3b ± *0.4*
Proportion of caecum (%)	36.9^{a} ± *0.5*	35.5^{ab} ± *0.6*	34.0b ± *0.6*
Proportion of large intestine (%)	14.4 ± *0.3*	14.1 ± *0.3*	14.6 ± *0.4*

[1)] Feed regardless AP4W
[2)] LSM with different letters in the same row are significantly different (P≤0.05)

%). Feed I and II seemed to be less convenient for weaning rabbits.

2 Effect of probiotic

The high growth of all trial animals indicated that rearing conditions were good; in such conditions probiotics had no important influence.

Addition of the probiotic influenced the proportions of stomach and caecum (Table 5). AP4W addition decreased the proportion of stomach and increased the proportion of caecum. CHEEKE *et al.* (1989) reported a decreased intake of caecotrophes when either probiotics or acidifiers were added. Therefore we might conclude that the lower proportion of stomach in our trial was caused by the decreased quantity of caecotrophes in stomach. Similarly to our results, MAERTENS *et al.* (1994) found a heavier caecum in rabbits fed with probiotic Paciflor additive.

Other parameters were not affected by probiotic additive, what is in accordance with ZOCCARATO *et al.* (1995).

3 Effect of sex

The sex of rabbits influenced their caecum weight and the proportions of small intestine and caecum (Table 6). The caecum in females reached a higher weight, which agrees with the results of LOPEZ *et al.* (1988), who reported a higher weight and higher degree of maturity of the caecum in female rabbits. STRUKLEC *et al.* (1994) also reported heavier caecum (with content) in 84 days old females than in males. These results can be explained by different dynamic of caecum growth between sexes.

4 Effect of age

As expected, the dressing percentage in older rabbits was higher, mainly due to the lower GI tract weight and higher carcass weight (Table 7).

The influence of slaughter weight was eliminated through regression; the results indicate that the GI tract represents a lower proportion in older rabbits than in younger ones. VICENTE *et al.* (1989) found that the first part of the GI tract that reached its final weight was the small intestine, the next one was the stomach and the last were the caecum and large intestine. The small intestine reached its final weight at the 7^{th} week; growth of the caecum and stomach stopped after 9 weeks, while the colon and appendix were still growing (LEBAS and LAPLACE, 1972). Similarly our results showed an increased weight and proportion of the large intestine in older rabbits.

5 Effects of interactions

Because of relatively small number of animals per group, the influences of particular interaction can not be unequivocal evaluated. The experiment should be repeated with large number of animal per treatment.

Table 5: Influence of probiotic addition in feed on parameters tested

Parameter	No addition LSM[1)] ± SE n = 37	+ 0.5 % AP4W LSM ± SE n = 38
Proportion of stomach (%)	29.9^{a} ± 0.6	28.0^{b} ± 0.6
Proportion of caecum (%)	34.8^{a} ± 0.4	36.2^{b} ± 0.4

[1)] LSM with different letters in the same row are significantly different (P≤0.05)

Table 6 : Influence of sex on parameters tested

Parameter	Females LSM[1)] ± SE n = 29	Males LSM± SE n = 46
Caecum weight (g)	151.1^{a} ± *3.1*	138.2^{b} ± *2.5*
Proportion of small int. (%)	20.7^{a} ± *0.4*	21.7^{b} ± *0.3*
Proportion of caecum (%)	36.6^{a} ± *0.5*	34.4^{b} ± *0.4*

[1)] LSM with different letters in the same row are significantly different (P≤0.05)

Table 7: Influence of age at slaughter on parameters tested

Parameter	53 days n = 40 LSM[1)] ± SE	67 days n = 37 LSM ± SE
Dressing percentage (%)	49.9^a ± *0.5*	52.0^b ± *0.5*
Carcass weight (g)	961^a ± *8*	1007^b ± *9*
GI tract weight (g)	422.4^a ± *8.2*	392.7^b ± *9.1*
Small intestine weight (g)	92.1^a ± *2.1*	80.0^b ± *2.3*
Large intestine weight (g)	54.8^a ± *1.4*	63.0^b ± *1.5*
Proportion of large int. (%)	13.8^a ± *0.3*	14.9^b ± *0.3*

[1)]LSM with different letters in the same row are significantly different ($P \leq 0.05$)

5.1 Interaction between feed and probiotic

The effect of probiotic addition was significant mainly with feed II, where its influence was as a whole negative (Table 8). In feeds I and III the probiotic had the opposite (positive) influence, but was mainly non significant: AP4W significantly decreased only the weight of the total GI tract and small intestine when added to feed III.

5.2 Interaction between age and feed

Differences in stomach weight and in the proportion of the small intestine when comparing different feeds were not expressed before the age of 67 days (Table 9). Rabbits require a longer period to adapt to a particular feed. GIDENNE (1992) found good adaptability of the GI tract to feed in growing rabbits after 6 weeks of feeding.

5.3 Interactions between age and probiotic and age and sex

These effects showed (Table 10 and 11) that differences were greater in younger animals and became non significant in older rabbits. Differences in the proportion of caecum between the sexes in younger rabbits (Table 11) probably originated from the faster caecum growth in females (LOPEZ *et al.*, 1988); later during the trial, these differences disappeared.

CONCLUSIONS

Feed (ADF and energy level) had a significant influence on the tested parameters in growing rabbits. Under experimental conditions the best results were obtained with high-energy/recommended-ADF feed (feed III). Rabbits in group III had the highest carcass weight and dressing

Table 8 : Effect of interaction between feed and probiotic AP4W on parameters tested (LSM ± SE)

Parameter	Feed I[(1)] without n = 14	Feed I + AP4W n = 14	Feed II without n = 12	Feed II +AP4W n = 11	Feed III without n = 11	Feed III +AP4W n = 13
Dressing percentage (%)	49.9 ± *0.5*	50.7 ± *0.5*	52.0^a ± *0.6*	49.3^b ± *0.6*	51.4 ± *0.6*	52.5 ± *0.6*
Carcass weight (g)	965 ± *10*	975 ± *10*	1002^a ± *11*	951^b ± *11*	994 ± *11*	1016 ± *11*
GI tract weight	416.1 ± *9.9*	406.2 ± *9.8*	398.7^a ± *10.2*	441.7^b ± *11.2*	407.8^a ± *11*	374.9^b ± *11*
Small intestine weight (g)	87.7 ± *2.5*	84.9 ± *2.5*	84.2 ± *2.7*	90.9 ± *2.9*	88.4^a ± *2.8*	80.3^b ± *2.8*
Caecum weight (g)	153.7 ± *4.0*	149.0 ± *4.4*	135.7^a ± *4.8*	161.9^b ± *5.0*	137.6 ± *5.0*	129.8 ± *4.9*
Large intestine weight (g)	56.7 ± *2.3*	56.3 ± *2.3*	53.7^a ± *2.5*	64.3^b ± *2.6*	62.8 ± *2.5*	59.7 ± *2.4*
Proportion of caecum (%)	37.1 ± *0.7*	36.8 ± *0.7*	34.1^a ± *0.8*	37.0^b ± *0.8*	33.4 ± *0.8*	34.7 ± *0.8*

[(1)]LSM with different letters are significantly different ($P \leq 0.05$)

Table 9 : Effect of interaction between age and feed on parameters tested

Parameter	Age (days) 53 / 57	Feed I[1)] LSM[2)] ± SE n = 14 / n = 14	Feed II[1)] LSM ± SE n = 13 / n = 10	Feed III[1)] LSM ± SE n = 13 / n = 11
Stomach weight (g)	53	118.9 ± *7.0*	125.7 ± *6.5*	128.5 ± *6.1*
	67	114.1^a ± *6.1*	124.3^a ± *7.4*	96.8^b ± *7.9*
% of stomach	53	27.5^a ± *1.0*	29.3^{ab} ± *1.0*	31.2^b ± *1.0*
	67	29.3 ± *1.0*	29.5 ± *1.1*	26.8 ± *1.1*
% of small intestine	53	20.3 ± *0.5*	21.3 ± *0.6*	21.3 ± *0.6*
	67	20.1^a ± *0.56*	21.0^a ± *0.6*	23.2^b ± *0.6*

[1)] Feed regarless AP4W
[2)]LSM with different letters in the same row are significantly different ($P \leq 0.05$)

Table 10: Effect of interaction between age and probiotic AP4W on parameters tested

Parameter	Age (days)	No addition LSM[1] ± SE	+ 0.5 % AP4W LSM ± SE
		n=20	n=20
Large intestine	53	51.9[a] ± *1.9*	57.7[b] ± *1.9*
weight (g)		n=17	n=18
	67	63.6 ± *2.1*	62.5 ±*2.1*

[1] LSM with different letters in the same row are significantly different (P≤0.05)

Table 11 : Effect of interaction between age and sex on parameters tested

Parameter	Age (days)	Females LSM[1] ± SE	Males LSM ± SE
Caecum %	53	n = 16 37.2[a] ± *0.8*	n = 24 33.8[b] ± *0.6*
	67	n = 13 36.0 ± *0.8*	n = 22 35.0 ± *0.7*

[1]LSM with different letters in the same row are significantly different (P≤0.05)

percentage; the lower GI tract weight and lower caecum weight (despite lower feed intake of this group) indicated the lowest risk of digestive disturbances. On the basis of our results we can conclude, that in weaning rabbits fed with high energy feed (13 MJ DE/kg) minimal risk for digestive disturbances can be assured by sufficient ADF content in feed (over 20 %).

As the main effect the addition of the composed probiotic AP4W decreased the proportion of stomach with respect to total GI tract weight, probably due to the lower intake of caecotrophes. The proportion of caecum was higher in rabbits with added probiotic.

The sex (as the main effect) of rabbits influenced some parameters: females had a higher weight and proportion of caecum and a lower proportion of small intestine. To confirm differences between sexes more experiments should be conducted. But even on the basis of our results together with the findings described in the available literature, we can recommend standardization of sex for nutritional trials with growing rabbits.

Older rabbits had a better dressing percentage, mainly due to their lower GI tract and higher carcass weight. The weight and proportion of the large intestine increased, and the proportion of the small intestine decreased from the 53rd to 67th day of age.

The effect of probiotic addition was significant only with feed II, where it had a negative influence in general. In other feeds (feed I and III) probiotic significantly decreased only the weight of the GI tract and small intestine when added to feed III.

ACKNOWLEDGMENTS : This investigation was funded by research grants from the Ministry of Science and Technology and the Ministry of Agriculture, Forestry and Food of Slovenia.

Received : February 10, 1995.
Accepted : September 19, 1996.

REFERENCES

CANDAU M., DELPON G., FIORAMONTI J., 1979. Influence of the nature of cell wall carbohydrates on the anatomico-functional development of the digestive tract in the rabbit. *Ann. Zootech., 28 (1), 127.*

CHEEKE P.R., 1987. Rabbit feeding and nutrition. *Orlando, Academic Press, 372 pp.*

CHEEKE P.R., HOLISTER A.G., ROBINSON K.L., 1989. Improving feed efficiency and reducing mortality in rabbits. A case study for use in all species. *In: Lyons, T.P. (Ed.) Biotechnology in the feed industry: Proceedings of Alltech's fifth annual symposium. Alltech Technical publications. Nicholasville, Kentucky, 1989, 253-259.*

CHEEKE P.R., PATTON N.M., 1980. Carbohydrate overload of the hindgut - a probable cause of enteritis. *J. Appl. Rabbit Res., 3 (3), 20-23.*

De BLAS J.C., SANTOMA G., CARABAÑO R., FRAGA M.J., 1986. Fiber and starch levels in fattening rabbit diets. *J. Anim. Sci., 63 (6), 1897-1904.*

DEHALLE C., 1981. Equilibre entre les apports azotés et énergétiques dans l'alimenatiton du lapin en croissance. *Ann. Zootech., 30 (2), 197-208.*

EL HINDAWY M.M., YAMANI K.A., TAWFEEK M.I., 1993. Effect of probiotic (Lacto-Sacc) in diets with different protein levels on growth performance, digestibility and some carcass aspects of growing rabbits. *Egypt. J Rabbit Sci., 3(1), 13-28.*

FOX P.M., 1988. Probiotics: intestinal inoculants for production animals. *Vet. Med., 83(8), 806-830.*

FRAGA M.J., PEREZ de AYALA P., CARABAÑO R., De BLAS J.C., 1991. Effect of type of fiber on the rate of passage and on the contribution of soft feces to nutrient intake of finishing rabbits. *J. Anim. Sci., 69 (4), 1566-1574.*

GARCIA J., De BLAS J.C., CARABAÑO R., GARCIA P., 1994. Effect of chemical composition of alfalfa hay on several digestive measurements in growing rabbits. *Cahier Options Mediterraneennes, 8, 151-155.*

GARCIA J., De BLAS J.C., CARABAÑO R., GARCIA P., 1995. Effect of lucerne hay on caecal fermentation and nitrogen contribution through caecotrophy in rabbits. *Reprod. Nutr. Dev., 35, 267-275.*

GARCIA G., GALVEZ J.F., De BLAS J.C., 1993. Effect of substitution of sugar beet pulp for barley in diets for finishing rabbits on growth performance and on energy and nitrogen efficiency. *J. Anim. Sci., 71 (7), 1823-1830.*

GIDENNE T., 1992. Effect of fibre level, particle size and adaptation period on digestibility and rate of passage as measured at the ileum and in the faeces in the adult rabbit. *Br. J. Nutr., 67 (1), 133-146.*

GIDENNE T., 1993. Measurement of the rate of passage in restricted-fed rabbits: effect of dietary cell wall level on the transit of fibre particles of different sizes. *Anim. Feed Sci. Technol., 42 (1-2), 151-163.*

GIDENNE T, PEREZ J.M., 1994. Apports de lignines et alimentation du lapin en croissance. 1. Consequence sur la digestion et le transit. *Ann. Zootech., 43 (4), 313-322.*

GIPPERT T,. VIRAG Gy., NAGY I., 1992. Lacto-Sacc in rabbit nutrition. *J. Appl. Rabbit Res., 15, 1101-1104*

HOOVER W.H., HEITMANN R.N. 1972. Effects of dietary fiber levels on weight gain, caecal volume and volatile fatty acid production in rabbits. *J. Nutr., 102 (3), 375-379.*

LAPLACE J.P., 1978. Le transit digestif chez les monogastriques. III Comportement (prise de nourriture - caecotrophie), motricité et transit digestif, et pathogénie des diahrées chez le Lapin. *Ann. Zootech., **27 (2)**, 225-265.*

LEBAS F., 1991. Troubles digestif du lapin: le rôle d'alimentation et les coccidies. Les problèmes pathologiques liés à l'alimentation. *Cuniculture **18, 101**, 232-237.*

LEBAS F., LAPLACE J.P., 1972. Mensuration viscérales chez le lapin. *Ann. Zootech., **21 (1)**, 37-47.*

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'age des animaux et de la séquence des régimes alimentaires. *Ann. Zootech., **31 (3)**, 233-256.*

LOPEZ A., DELTORO J., CAMACHO J., 1988. Quantitative growth of rabbit organs. *Proc. 4th World Rabbit Congr., Budapest, Vol. 2, 370-378.*

LYONS T.P., 1987. Probiotics: an alternative to antibiotics. *Pig News Inf., 8 (2), 157-164.*

MAERTENS L., 1995. Energy and nutrient requirements of does and their young. *In: 9. Arbetstagung über Haltung und Krankheiten der Kaninchen, Pelztiere und Heimtiere. Celle, 1995-05-10/11, Giessen, DVG, 76-91.*

MAERTENS L., De GROOTE G., 1992. Effect of dietary supplementation of live yeast on the zootechnical performances of does and weanling rabbits. *J. Appl. Rabbit Res., **15**, 1079-1086.*

MAERTENS L., van RENTERGHEM R., de GROOTE G., 1994. Effect of dietary inclusion of Paciflor (*Bacillus* CIP 5832) on the milk composition and performances of does and on caecal and growth parameters of their weanlings. *World Rabbit Sci., **2 (2)**, 67-73.*

SAS/STAT, 1990. User's guide. *SAS Institute inc., Cary, North Carolina, USA*

SCHLOLAUT W., 1982. The nutrition of the rabbit. *Roche, Information Service, Animal Nutrition Department, Basel, 60 pp.*

STRUKLEC M., KERMAUNER A., MARINSEK-LOGAR R., 1994. The effect of corn, barley or oats on digestion process and production parameters of growing rabbits. *Znan. prak. poljopr. tehnol. 24(1), 128-135.*

VICENTE J.S., PERIS J.L., CAMACHO J., 1989. Digestive tract growth in meat rabbits. *J. Appl. Rabbit Res., 12 (3), 177-180*

ZOCCARATO I., BARBERA S., TARTARI E., 1995. Effeto dell'impiego di mangime contenente un'associazione antibiotico-probiotico sulle performance del coniglio all'ingrasso. (Effect of dietary inclusion of an antibiotic-probiotic combination on fattening rabbit performance.) *Zootecnica e Nutrizione Animale, **21 (5)**, 297-304.*

YAMANI K.A., IBRAHIM H., RASHWAN A.A., EL-GENDY K.M., 1992. Effects of a pelleted diet supplemented with probiotic (LACTO-SACC) and water supplemented with a combination of probiotic and acidifier (Acid-Pak 4-Way) on digestibility, growth, carcass and physiological aspects of weanling New Zealand White rabbits. *J. Appl. Rabbit Res., **15**, 1087-1100*