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THREONINE : AN ESSENTIAL AMINO ACID NOT FREQUENTLY USED TILL NOW IN RABBIT FEEDS FORMULATION. A REVIEW

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ABSTRACT: Lactating doe and growing-finishing rabbit threonine requirements have been studied through a review of the original researches dealing with this topic. Threonine is confirmed as being an essential amino acid to rabbit milk production and growth. Threonine requirement can be evaluated at 0.64% of the feed for the lactating doe and at 0.60% for the growing-finishing rabbit. However, growth and milk production variations with dietary threonine level remain limited. Expressed in percentage of the crude protein, the threonine requirement of the rabbit (3.7%) is higher than those for the pig or chicken. This fact may be a consequence of the high threonine level of rabbit meat. This study confirms a light depressing effect of an excess of threonine in the feed (above 0.65-0.70%). On a practical point of view, a purified threonine supplementation may be necessary particularly in the lactating does' feeds, mainly when low alfalfa incorporation is used.

RESUME: La thréonine : un acide aminé indispensable encore peu utilisé dans la formulation des aliments destinés aux lapins, une revue
Les différents travaux originaux réalisés sur les besoins en thréonine de la Lapine allaitante et du Lapin en post-sevrage ont été analysés. L'ensemble de ces travaux confirme que la thréonine est un acide aminé indispensable à la lactation et à la croissance du lapin. Les besoins en thréonine du Lapin sont ainsi évalués à environ 0,64% de l'aliment pour la lapine allaitante et 0,60% pour le Lapin en croissance. Les variations de performances en fonction du taux de thréonine sont toutefois d'amplitude limitée. Rapporté aux protéines, le besoin en thréonine du Lapin (3,7%) est plus élevé que celui du porc ou du poulet, ce qui peut s'expliquer par la richesse en thréonine de la viande de lapin. Cette synthèse confirme également l'effet légèrement dépressif de taux trop élevés de thréonine dans l'aliment (plus de 0,65-0,70%). D'un point de vue pratique, une supplémentation par de la thréonine purifiée peut s'avérer nécessaire particulièrement pour les aliments de lactation surtout lorsque le taux de l'aliment en luzerne déshydratée est bas.

INTRODUCTION

The rabbit's essential amino acids requirements have been studied in different scientific researches. First, they were focused on lysine and sulphur amino acids requirements (COLIN 1978) but recently, they have also studied the threonine levels. As a matter of fact, several works on poultry (LECLERCQ 1998) and in pigs (WANG and FULLER 1989; FULLER *et* al 1989) have shown there is a high threonine requirement for growing animals.

As an essential amino acid, the threonine is not synthesised by the monogastric animals. Since 30 to 40 per cent of the rabbit feed is derived from cereals and their by-products, the protein of which is strongly threonine deficient (table 1), threonine must be added to the feed. Moreover, in order to diversify the crude fiber supply, a part of alfalfa is often substituted by alternative ingredients as grape marc (PARIGI BINI et CHIERICATO, 1980) from which the proteins are poor in threonine. In the same way, in 1988, BERCHICHE *et al* and LEBAS reported respectively the possibility of a threonine deficiency in diet based on field beans or on chick-peas. Consequently, with the exception of alfalfa, the raw materials used in the practical rabbit diet are deficient in threonine. This point is very important because the threonine content in rabbit meat is particularly high (table 2).

Table 1 : Threonine content of some raw materials incorporated into rabbit feeds, of rabbit meat and milk and of soft faeces, compared to the rabbit nutritional requirements, according to PARIGI-BINI and CHIERICATO (1980); JANIERI (1987); COLIN (1978); I.N.R.A. (1989); KUSTOS *et al.* (1998).

Feed ingredients	Crude protein level % product	Threonine level % product	Threonine level % crude protein	Threonine in % ideal protein for rabbits
Alfalfa17	16.6	0.69	4.16	110
Grape marc	15.6	0.54	3.47	92
Soya 44 meal	43.2	1.68	3.89	103
Sunflower 30 meal	29	1.07	3.69	98
Horse beans	26.4	0.93	3.52	93
Wheat	11.3	0.34	3.01	80
Maize	9.0	0.32	3.56	94
Barley	10.8	0.33	3.06	81
Wheat bran	15.8	0.52	3.29	87
Rabbit meat	21.5	1.16	5.40	143
Rabbit milk	14	0.54	3.86	102
Soft faeces	30.7	1.82	5.93	157
Rabbit does requirements	17.5	0.66	3.77	*100*
Growing fattening rabbits requirements	15.9	0.60	3.77	*100*

Tableau 2 : Threonine composition of rabbit, chicken and pig meats, according to JANIERI (1987)

	Rabbit	Chicken	Pig
Protein % in meat	**21.5**	19.5	17.5
Threonine mg/100 g meat	**1160**	854	732
Threonine % protein	**5.40**	4.38	4.18

A supplementation with pure threonine appears to be often necessary to reach the animal requirements. Considering the cost of this amino acid, the right supplementation can be done only through a good knowledge of the nutritional requirements (LEWISS and SPEER, 1975; SALDANA *et al.*, 1994).

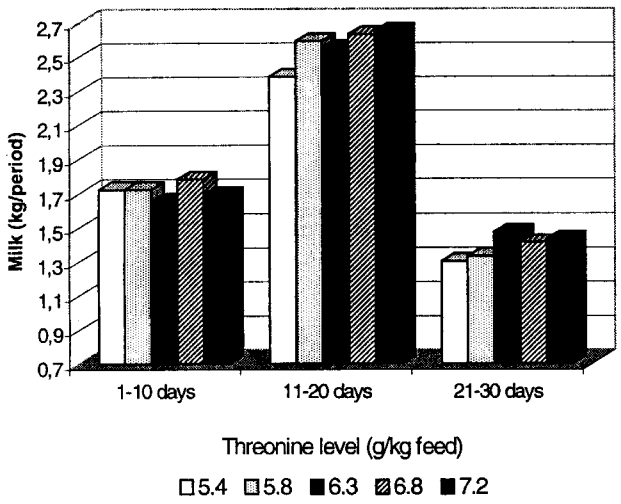

Figure 1: Milk production of does in relation with dietary threonine level, according to DE BLAS *et al.*, 1998).

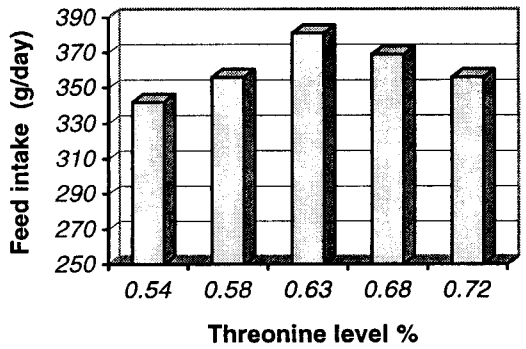

Figure 2 : Does feed intakes between parturition and the 30th days of lactation in relationships with the feed threonine level, according to DE BLAS *et al.* (1998).

THREONINE REQUIREMENT OF THE LACTATING DOE.

As mentioned by XICCATO (1996) during the 6th world rabbit congress, few researchers deal with the threonine lactating doe requirement.

In 1996 and 1998, DE BLAS *et al* have presented the effects of the feed threonine level on the reproductive performances of 240 does (46 to 50 does per experimental feed). The studied levels were distributed between 0.54% and 0.72% of threonine in a feed containing 14.8% crude protein and 10.1 MJ /kg digestible energy (2413 kcal/kg). Furthermore, the milk production between parturition and the 30th day has been registered for 16 does of each treatment.

According to these authors, the feed threonine level does not improve significantly the total milk production (1-30 days). However, the threonine level has a significant effect on milk production between 11 and 20 days of lactation (figure 1) and during the 20 first days. The highest milk production was registered with 0.68% of threonine in the feed for the cumulated 2 first periods (220.5 g/day *vs* 205 to 217 g/day in average); but for the last 10 days of lactation, milk production was maximum with 0.63% of threonine in the feed.

The highest feed intake (381 g/day) was obtained with 0.63% of threonine (figure 2). At lower levels, the does consume less and consequently lose weight, making more difficult the following reproductive performances and increasing the elimination percentage.

Dealing with the rabbit growth before weaning, the total litter weights at 21 days (LW21) and at weaning (LW30) vary with the threonine level. In the following 2nd degree equations, litter weights are expressed in kg and threonine content (Thr) in g/kg feed :

$$LW21 = -08.0\ (\pm 4.6) + 3.4\ (\pm 1.5)\ Thr - 0.27\ (\pm 0.12)\ Thr^2$$
$$LW30 = -17.0\ (\pm 9.1) + 6.9\ (\pm 2.9)\ Thr - 0.53\ (\pm 0.23)\ Thr^2$$

In these 2 equations, the total litter weight is the highest with 0.64% and 0.65% of threonine in the feed, for LW21 and LW30 respectively.

The highest number of weaned rabbits and the lowest mortality before weaning (figure 4) were obtained for 0.63% of threonine in the diet.

In contrast, higher threonine levels have a depressive effect on the young rabbits growth (figure 3).

Summarizing, even if the authors consider that « Dietary threonine content did not affect feed intake of does, total or maximal milk production», the reproductive results are higher with 0.58% or with 0.63% of threonine than with 0.54%. The differences are greater during the second suckling period (11-20 days) than during the complete one indicating a

higher threonine requirement of the doe at this stage of lactation. With lower threonine levels (lower than 0.58%), the feed intake and the weight of the does decreases during the reproductive cycle. Since these trials were carried out with a quite low crude protein level in the feed to emphasize the possible threonine deficiencies, this method may simultaneously provoke an unbalance in other secondary limiting amino acids and consequently may slightly underestimate the lactating doe threonine requirement.

The authors have directly determined the digestibility of the threonine brought either by the basic ration ingredients (apparent digestibility of 63.8%) or as added pure threonine (apparent digestibility of 93%). It would be obviously better to formulate the rabbit threonine requirement as a digestible threonine requirement. Such method is practically difficult to use because of the lack of suitable nutritional tables concerning the digestible threonine content of raw materials.

In conclusion, for 10.12 MJ /kg (2413 kcal/kg) digestible energy feed as employed in the DE BLAS *et al.* experiments, the lactating does' threonine requirement can be evaluated at the following levels:

- 0.64% of total threonine in the feed.
- 0.44% of digestible threonine in the feed.
- 0.64 grams /MJ of digestible energy.
- 2.69 grams/1000 kcal of digestible energy.

REQUIREMENT OF GROWING - FINISHING RABBITS

The growing-finishing rabbit threonine requirements have been studied more extensively than those of the doe. The first direct determination has been carried out by ADAMSON *et* FISHER, (1973) using a synthetics diet. Practical recommendation has been estimated at 0.55% of the diet. Such a value has been indirectly confirmed by DAVIDSON *et* SPREADBURY (1975) and by COLIN, (1978).

Recently, BRIENS, (1996) and DE BLAS *et al.*, (1998) have determinate the threonine requirements of growing rabbits fed with a practical diet. BERCHICHE, (1985), MAERTENS and LUZI, (1996) and MONTESSUY *et al.*, (2000) have studied the effect of dietary protein and threonine levels on the growth and the feed intake (figures 5, 6 and 7) of growing-finishing rabbits.

Furthermore the particulars conditions of some trials and in order to emphasise the general tendencies, the different results of BRIENS, (1996), DE BLAS *et al.*, (1998) and of MONTESSUY *et al.*, (2000) have been gathered: for every criteria and for

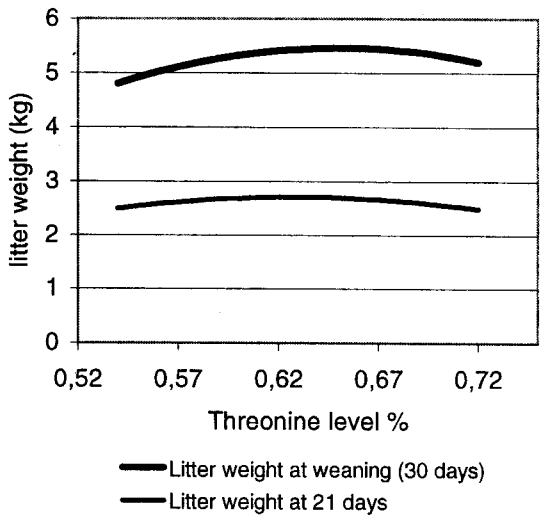

Figure 3 : Relationships between the feed threonine level and the total litter weight at 21 and 30 days, according to DE BLAS *et al.* (1998)

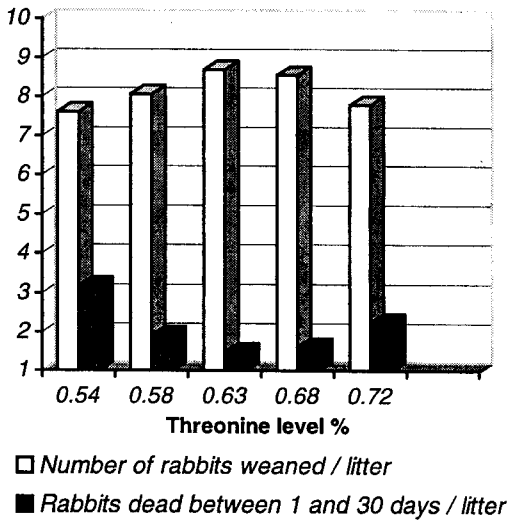

Figure 4 : Effect of threonine on weaning litter size and on the number of rabbits that died before weaning, according to DE BLAS *et al.*, 1998).

every experiment, the results have been expressed in percentage of the result got with 0,58% of threonine. In a second step, the relationship between the dietary threonine content and these percentages have been studied using analyses of variance/correlation of these standardized data.

- **Feed intake**

Dietary threonine content has little influence feed intake during the post-weaning (up to 45-50 days) and the whole fattening periods. The quadratic effect is at the limit of statistical signification (figure 5) and can be considered as a tendency (Significant quadratic effect at P=0.056; P=0.096 for the crude threonine level at the 1st degree and P=0.093 for the quadratic one). The highest feed intake has been observed for 0.58% of dietary crude threonine. Feed intakes are slightly depressed by higher levels.

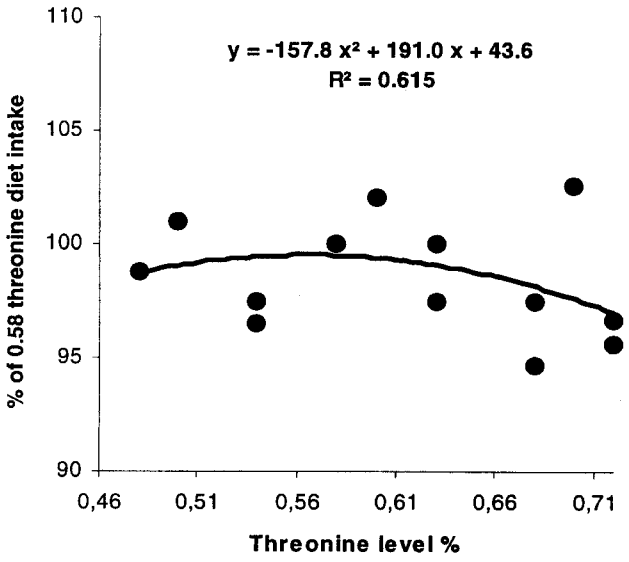

Figure 5 : Feed intake of rabbits during the growing-fattening period in percentage of results observed with a 0.58% threonine diet, according to BRIENS, (1996); DE BLAS *et al.*, (1998); MONTESSUY *et al.*, (2000).

- **Growth (ADG)**

Using the same method, the average daily growth (ADG) appears only slightly but significantly improved when the crude threonine goes up till 0.60% (figure 6). Up this level, the increase of the threonine level has a light depressive effect. The 2nd degree equations show a significant ADG evolution with the threonine level (Significant quadratic effect at P=0.047; P=0.032 for the crude threonine level at the 1st degree and P=0.033 for the quadratic one). The highest growths either for the post-weaning period or for the finishing-period were observed for 0.60% of crude threonine in the feed.

- **Feed efficiency**

During the post weaning period (till 45-50 days), the feed efficiency was slightly but significantly improved (P=0.013) when threonine level increased. At contrary, for the whole period from weaning till slaughter age, no significant variation (P>0.20) has been found between feed efficiency and dietary threonine level (figure 7).

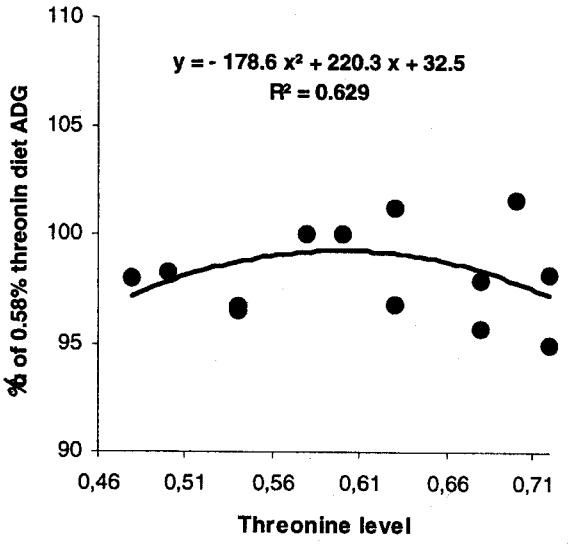

Figure 6 : Average daily growth (ADG) of rabbits during the growing-fattening period in percentage of the results observed with a 0.58% crude threonine diet, according to BRIENS, (1996); DE BLAS *et al.*, (1998); MONTESSUY *et al.*, (2000).

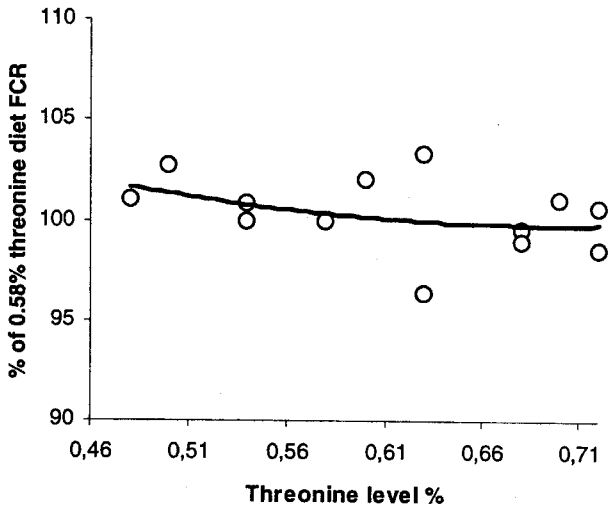

Figure 7 : Feed conversion ratio (FCR) during the growing-fattening period in percentage of the results observed using with a 0.58% crude threonine diet, according to BRIENS, (1996); DE BLAS *et al.*, (1998); MONTESSUY *et al.*, (2000

- **Carcass quality and dressing percentage**

According to DE BLAS *et al.*, (1998), neither the carcass dressing percentage, nor the primal joints percentage in the dressed carcass were affected by the dietary threonine content (figure 8). However the highest perirenal fat has been obtained with 0.63% of dietary crude threonine.

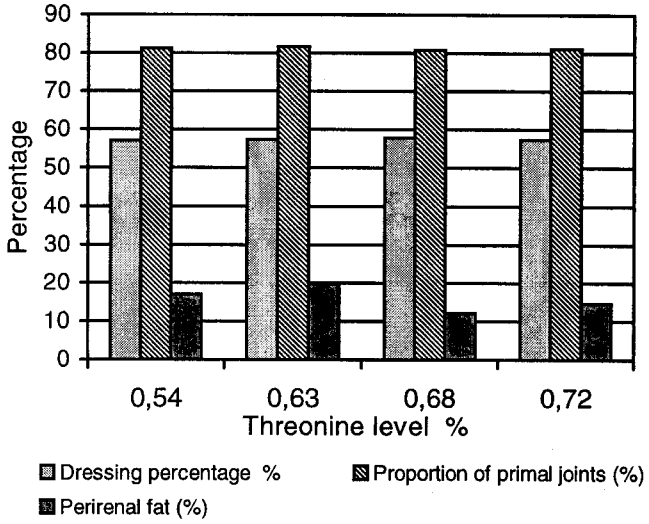

Figure 8 : Effect of the dietary threonine content on the rabbit carcass characteristics according to DE BLAS *et al.*, (1998)

- **Conclusions for the growing-finishing rabbits**

In conclusion, for growing-finishing rabbits the growth performances are less affected by the dietary threonine than the lactating does. The growth and feed intake highest values have been observed between 0.58 and 0.60% of threonine in the feed.

Both lower and higher levels of threonine have slightly depressing effects on the performances. These results are similar to those observed for the pig (LEWISS and SPEER, 1975; SALDANA *et al.*, 1994).

The requirements of growing - finishing rabbits can be estimated at:

- 0.60% of crude threonine in the feed.
- 0.40% of digestible threonine in the feed.
- 0.64 grams /MJ of digestible energy.
- 2.69 grams/1000 kcal of digestible energy.

CONCLUSIONS

In conclusion, this review confirms that the threonine requirements are about 0.64% of the feed for the lactating doe and about 0.60% for the growing-finishing rabbit. These values are slightly lower than those previously reported in the literature for the lactating does and a little bit higher for the growing-finishing rabbits (table 3). These differences confirm too that a threonine excess decreases feed intake, growth and milk production. However, the performance variations with the threonine content are limited at least in the area corresponding to the practical rabbit feeds.

Expressed as percentage of the crude proteins, the threonine requirement of the rabbit is higher than for the pig and slightly higher than that of the broiler chicken (table°4). Additionally, the threonine to lysine ratio is clearly higher for the rabbit than for the other species. This observation seems to be a paradox because the rabbit's soft faeces have a very high threonine level representing a supplementation in this amino acid. It can be explained by the high threonine level of rabbit meat compared to that of pig or broiler (table 2).

On a practical point of view, a purified threonine supplementation is often necessary in the rabbit feeds, particularly in the lactating does diet. When there is a lower alfalfa level in the feed, there has to be a higher purified threonine incorporation (table 5). Consequently, the feed threonine level has to be checked every time the alfalfa level is reduced.

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Table 3 : Threonine requirements of the rabbit according to different authors

Authors	Years	Suckling does	Renewing does	Growing finishing	Unic
ADAMSON and FISHER	1973			0.55	
DAVIDSON and SPREADBURY	1975			0.58	
COLIN	1978			0.55	
INRA	1989	0.70		0.55	0.60
De BLAS *et al*	1998	0.64		0.60	
De BLAS and MATEOS	1998	0.70		0.64	0.68
MAERTENS	1998	0.70	0.58		
Current work	***2001***	***0.64***		***0.60***	

Table 4 : Proteins, threonine and lysine requirements of rabbit, broiler and pig (According to I.N.R.A., 1989)

	Rabbit	Chicken	Pig
Crude Protein requirement % in diet	16,5	19,4	17
Lysine requirement % diet	0.72	0.97	0.8
Threonine requirement % diet	0.60 (1)	0.67	0.50
Threonine % crude proteins	3,7 (1)	3,45	2,94
Threonine /Lysine ratio	0.83 (1)	0.69	0.63

(1) Current work

Table 5 : Effects of alfalfa level variation on purified threonine need of incorporation in a rabbit does feed

Alfalfa level % in diet	25	30	35	40
Target diet's threonine level (%)	0,66			
Addition of purified threonine required in a suckling doe feed (% diet)	0,063	0,035	0,024	0,022

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