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# FEEDING PLANS AT DIFFERENT PROTEIN LEVELS: EFFECTS ON GROWTH PERFORMANCE, MEAT QUALITY AND NITROGEN EXCRETION IN RABBITS

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**ABSTRACT**

The effects of a reduction of dietary protein on productive performance, nitrogen excretion, carcass and meat quality were evaluated on 120 rabbits. From 35 to 56 d of age, they were divided into two groups fed diet H1 (high protein: 15.6% CP; DP/DE: 11.5 g/MJ) and diet M1 (moderate protein 14.4% CP; DP/DE: 10.5 g/MJ). From 56 d to slaughter (77 d), the rabbits were divided into three groups fed diet H2 (high protein: 15.4% CP; DP/DE: 10.6 g/MJ), diet M2 (moderate protein: 14.3% CP; DP/DE 9.9 g/MJ) and diet L2 (low protein: 13.1% CP; DP/DE: 8.7 g/MJ). During the first period, the protein level affected growth and feed efficiency, being daily weight gain higher (45.6 *vs* 43.7 g/d; $P<0.05$) and conversion index lower (3.21 vs 3.35) in the H1 group in comparison with M1 group. Carcass and meat quality were not influenced, apart from a lower fat content observed in the H1 group. Despite the large protein range tested in the second period, no influence on productive performances was observed. However, a depression of muscular growth resulted with the lowest protein diet.
During the first period, both nitrogen excretion and retention decreased (-7 and -6%, respectively) as dietary protein levels lowered, evidencing a protein lack. In the second period, the strong reduction of dietary protein below recommendations allowed a reduction of nitrogen excretion by 9%, without effects on nitrogen retention, in the rabbits fed diet M2, and by 15% with a 3% reduction of nitrogen retention in the rabbits fed diet L2.

## INTRODUCTION

The interest of researchers in rabbit nutrition towards the estimation of protein requirements has been recently renewed because of various reasons. First of all, the most used protein recommendations (LEBAS, 1989) refer to rabbits belonging to genetic types whose productive performances were lower compared to those of the actual hybrids specialised in meat production. In commercial feeds, protein levels are usually above the requirements stated for the post-weaning period and remain constant until slaughter in order to assure the maximum growth. However, the growing attention towards the environmental impact of livestock production imposes a better evaluation of the nutrient input. The availability of synthetic amino acids (AA) permits to formulate low protein diets, assuring an adequate supply of the most limiting ones, whose requirements have been recently reviewed (MAERTENS, 1999).
MAERTENS *et al.* (1997) reduced dietary crude protein (CP) up to 15.7% in diets supplemented with limiting AA without compromising productive performances, in the meanwhile lowering nitrogen excretion. As already hypothesised by PARIGI BINI *et al.* (1988), the age dependant response of rabbits to dietary protein or better to dietary AA was found by MAERTENS *et al.* (1997) and MAERTENS and LUZI (1997).The objective of the present work was to evaluate the effects of phase feeding plans based on different protein levels on growing rabbit performances, nitrogen excretion, carcass and meat quality. A secondary objective was to determine the optimal dietary protein level during both the first period, *i.e.* from 35 to 56 d of age, and the second period, from 56 d until slaughter.

## MATERIAL AND METHODS

One hundred twenty rabbits of a hybrid line (Grimaud) (live weight 817±61 g) were kept in individual cages under controlled environmental conditions. During the first period, from 35 to 56 d of age, the rabbits were divided into two homogeneous groups and fed diet H1 and M1, at high (15.6%) and medium (14.4%) CP concentration. During the second period (56 to 77 d), rabbits were fed three diets: H2, M2 and L2, with 15.4, 14.3, and 13.1% CP, respectively, obtaining 6 feeding plans: H1-H2; H1-M2; H1-L2; M1-H2; M1-M2; M1-L2.

**Table 1**. Percentage and chemical composition and nutritive value of the diets

| | Diet H1 | Diet M1 | Diet H2 | Diet M2 | Diet L2 |
|---|---|---|---|---|---|
| ***Ingredients:*** | | | | | |
| Dehydrated alfalfa, 17% CP | 32.00 | 32.00 | 22.0 | 22.00 | 22.00 |
| Barley (six rows) | 20.00 | 22.00 | 28.0 | 30.00 | 32.00 |
| Wheat bran | 24.00 | 24.00 | 24.0 | 24.00 | 24.00 |
| Soybean meal, 44% CP | 5.00 | 3.00 | 6.00 | 4.00 | 2.00 |
| Sunflower meal, 30% CP | 5.00 | 3.00 | 6.00 | 4.00 | 2.00 |
| Sugar beet pulp | 10.00 | 12.00 | 10.0 | 12.00 | 14.00 |
| Molasses | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Limestone | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Dibasic calcium phosphate | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| Salt | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 |
| Vitamin-mineral premix | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| DL-methionine | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| HCl-lysine | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Coccidiostatic | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| ***Chemical composition:*** | | | | | |
| Crude protein (CP), % | 15.6 | 14.4 | 15.4 | 14.3 | 13.1 |
| Ether extract, % | 2.31 | 2.20 | 2.1 | 1.5 | 2.0 |
| Crude fibre (CF), % | 15.2 | 15.5 | 12.9 | 13.7 | 12.7 |
| Gross energy (GE), MJ/kg | 16.49 | 16.37 | 16.47 | 16.32 | 16.32 |
| ***Nutritive value:*** | | | | | |
| DM digestibility, % | 62.8 | 61.5 | 63.6 | 63.6 | 63.5 |
| CP digestibility, % | 75.5 | 73.1 | 72.0 | 71.7 | 68.6 |
| CF digestibility, % | 24.5 | 23.7 | 16.4 | 23.4 | 18.3 |
| GE digestibility, % | 62.2 | 61.0 | 63.4 | 63.2 | 63.1 |
| Digestible energy (DE), MJ/kg | 10.26 | 9.99 | 10.45 | 10.31 | 10.29 |
| Metabolisable energy, MJ/kg | 9.64 | 9.44 | 9.87 | 9.77 | 9.80 |
| DP/DE, g/MJ | 11.48 | 10.54 | 10.61 | 9.94 | 8.73 |

All diets were supplemented with the same amount of HCl-lysine and DL-methionine (table 1) to maintain constant the lysine/CP (4.8 to 4.9%) and the methionine+cystine/CP ratios (4.1 to 4.3%). The calculated concentrations of lysine (0.68 to 0.77%) and methionine+cystine (0.60 to 0.70%) were consistent with the recommended values (DE BLAS and MATEOS, 1998). The digestibility and nutritive value of the diets were determined *in vivo* following the European standardized method (PEREZ *et al.*, 1995). The metabolizable energy concentration was calculated according to PEREZ *et al.* (1998).

At 77 d, 60 rabbits (10 per group) were slaughtered in a commercial slaughterhouse. Twenty-four hours later, they were dissected to obtain the reference carcass according to BLASCO *et al.* (1993). The ultimate pH, the L*a*b* colour, the cooking losses and the shear press force of

the hindleg were measured following the procedures described by XICCATO *et al.* (1994).
Diets and faeces were analysed as detailed by XICCATO *et al.* (1999). The experimental results were submitted to analysis of variance, using a bi-factorial model (2 diets of the first period x 3 diets of the second period) with interactions (SAS, 1990).
Nitrogen excretion was calculated by difference between ingested nitrogen and body retained nitrogen during the whole growing period. The empty body weight (EBW) was assumed to be 87% live weight (LW); the EBW protein concentration was considered equal to 20% and the nitrogen concentration of CP equal to 16% (PARIGI BINI and XICCATO, 1998).

## RESULTS AND DISCUSSION

**Chemical composition and nutritive value of the diets.** Table 1 reports the ingredients and chemical composition of the diets. The CP concentration of the diets was reduced by increasing barley and sugar beet pulp percentage in substitution of sunflower and soybean meal. To increase the energy value of the finishing diets in comparison with the post-weaning diets, a higher percentage of barley was included in substitution of dehydrated alfalfa meal.
The main differences in chemical composition were consistent with diet formulation: CP level decreased from diet H1 to diet M1 (15.6% to 14.4%) and from diet H2 to L2 (15.4% to 14.3% to 13.1%). The highest CP level was chosen based on the results of MAERTENS *et al.* (1997) who showed no performance impairment with a dietary protein equal to 15.7%. The very low CP concentration of diet L2 allowed to test a wide range of dietary protein, looking at the age dependant response of rabbits to dietary protein (PARIGI BINI *et* 1988; MAERTENS *et al.*, 1997). Crude fibre and DE concentration accounted for the main differences between the diets of the two periods. The DP/DE ratio of the diets of the second period was lower than the first period and below the recommended values (LEBAS, 1989).

**Productive performances.** The reduction of the protein concentration during the first period of growth strongly reduced rabbit productive performance with significant residual effects during the second period (table 2). Rabbits fed diet H1 showed higher daily weight gain (50.7 *vs* 47.7 g/d; P<0.01) in the first period and consequently higher live weight at 56 d. The same animals were still heavier (P=0.02) at 77 d of age. Feed intake was not influenced, while feed conversion was worse in rabbits fed diet M1.

**Table 2**. Productive performance of growing rabbits

| | Diet H1 | Diet M1 | Prob. | Diet H2 | Diet M2 | Diet L2 | Prob. | RSD |
|---|---|---|---|---|---|---|---|---|
| Live weight, g | | | | | | | | |
| 35 days | 822 | 809 | 0.29 | 825 | 803 | 818 | 0.37 | 60 |
| 56 days | 1886 | 1812 | <0.01 | 1856 | 1824 | 1867 | 0.37 | 129 |
| 77 days, g | 2740 | 2646 | 0.02 | 2711 | 2677 | 2691 | 0.79 | 190 |
| Daily weight gain, g/d | | | | | | | | |
| from 35 to 56 d | 50.7 | 47.7 | 0.01 | 49.1 | 48.6 | 50.0 | 0.58 | 5.4 |
| from 56 to 77 d | 40.6 | 39.7 | 0.41 | 40.7 | 40.6 | 39.2 | 0.48 | 5.4 |
| from 35 to 77 d | 45.6 | 43.7 | 0.03 | 44.9 | 44.6 | 44.6 | 0.96 | 4.4 |
| Feed intake, g/d | | | | | | | | |
| from 35 to 56 d | 124 | 126 | 0.32 | 126 | 124 | 125 | 0.75 | 11 |
| from 56 to 77 d | 168 | 166 | 0.63 | 167 | 169 | 164 | 0.54 | 17 |
| from 35 to 77 d | 146 | 146 | 0.91 | 147 | 147 | 145 | 0.74 | 12 |
| Feed conversion index | | | | | | | | |
| from 35 to 56 d | 2.47 | 2.66 | <0.01 | 2.60 | 2.57 | 2.53 | 0.68 | 0.31 |
| from 56 to 77 d | 3.67 | 3.79 | 0.01 | 3.74 | 3.78 | 3.68 | 0.26 | 0.24 |
| from 35 to 77 d | 3.21 | 3.35 | <0.01 | 3.28 | 3.29 | 3.26 | 0.80 | 0.22 |

The reduction of dietary protein during the second period did not modify productive performances. No interaction between the diets of the two periods was found.

In agreement with the results of MAERTENS *et al.* (1997), a dietary protein level below 15.6% impaired productive performance during the first period. During the second period, on the contrary, even a protein level (13.1%) strongly below the usual recommendations (15-16%) did not affect growth performance. These results confirmed a clear differentiation of protein requirements in rabbits during the two phases of growth, as shown by few authors before (PARIGI BINI *et al*., 1988; MAERTENS *et al*., 1997). During the second period, the rabbits subjected to protein lack in the first period did not show any compensatory growth, despite other findings (PARIGI BINI *et al*., 1988; OUHAYOUN, 1989). Therefore, the major importance of the dietary protein level during the first period of growth was outlined.

**Carcass and meat quality.** Dressing out percentages were good for both rabbits fed diet H1 and M1 (about 61%) (table 3). The only significant difference concerned the incidence of dissectable fat (2.65% *vs* 2.91% for diet H1 and M1, respectively; P=0.07). No significant effect was recorded on meat quality as a consequence of the protein level of the first period.

In agreement with MAERTENS *et al.* (1997), in our study the reduction of the dietary protein level during the first period did not modify dressing out percentage. On the contrary, OUHAYOUN (1989) reported worse slaughter results due to the impairment of productive performance. Moreover, LEBAS and OUHAYOUN (1987) observed a reduction in carcass adiposity with low protein diets due to the delay induced in muscle growth and fat deposition.

The dietary protein level of the second period slightly affected carcass and meat quality (table 3). The lowest protein level (diet L2) reduced dressing out percentage (60.3%) compared to diets H2 and M2 (61.3% on average, P=0.12) mainly due to the higher gut incidence (18.7% *vs* 17.5% on average in H2 and M2 groups; P<0.05). Moreover, decreasing protein levels determined a reduction of the meat to bone ratio of hindleg, from 5.55 to 5.32 to 5.11 (P=0.06). Rabbits fed diet L2 also showed a lower incidence of the *longissimus dorsi* muscle (11.8 *vs* 12.5% on average in M2 and H2 groups; P=0.05).

**Table 3.** Carcass and meat quality

| | Diet H1 | Diet M1 | Prob. | Diet H2 | Diet M2 | Diet L2 | Prob. | RSD |
|---|---|---|---|---|---|---|---|---|
| Slaughter weight (SW), g | 2663 | 2578 | 0.21 | 2644 | 2603 | 2614 | 0.87 | 204 |
| Dressing out percentage, %SW | 60.7 | 61.1 | 0.44 | 61.2 | 61.3 | 60.2 | 0.12 | 1.4 |
| Reference carcass (RC), g | 1304 | 1270 | 0.34 | 1311 | 1284 | 1265 | 0.61 | 110 |
| Dissectable fat, %RC | 2.65 | 2.91 | 0.07 | 2.84 | 2.83 | 2.67 | 0.61 | 0.45 |
| Hindlegs, %RC | 33.2 | 33.3 | 0.73 | 33.5 | 33.0 | 33.2 | 0.34 | 0.9 |
| *Longissimus dorsi,* %RC | 12.4 | 12.2 | 0.45 | 12.6 | 12.4 | 11.8 | 0.05 | 0.8 |
| M/B of hindleg | 5.31 | 5.33 | 0.91 | 5.55 | 5.32 | 5.11 | 0.06 | 0.43 |
| *Biceps femoris* | | | | | | | | |
| $pH_u$ | 5.85 | 5.89 | 0.39 | 5.87 | 5.86 | 5.89 | 0.79 | 0.12 |
| $L^*$ | 55.5 | 55.2 | 0.64 | 55.0 | 54.6 | 56.3 | 0.06 | 1.87 |
| $a^*$ | 3.42 | 3.41 | 0.99 | 3.66 | 3.40 | 3.18 | 0.64 | 1.22 |
| $b^*$ | -0.16 | -0.19 | 0.42 | -0.08 | 0.05 | 0.08 | 0.95 | 1.32 |
| Shear press force, $kg/cm^2$ | 1.34 | 1.21 | 0.20 | 1.32 | 1.17 | 1.33 | 0.37 | 0.03 |

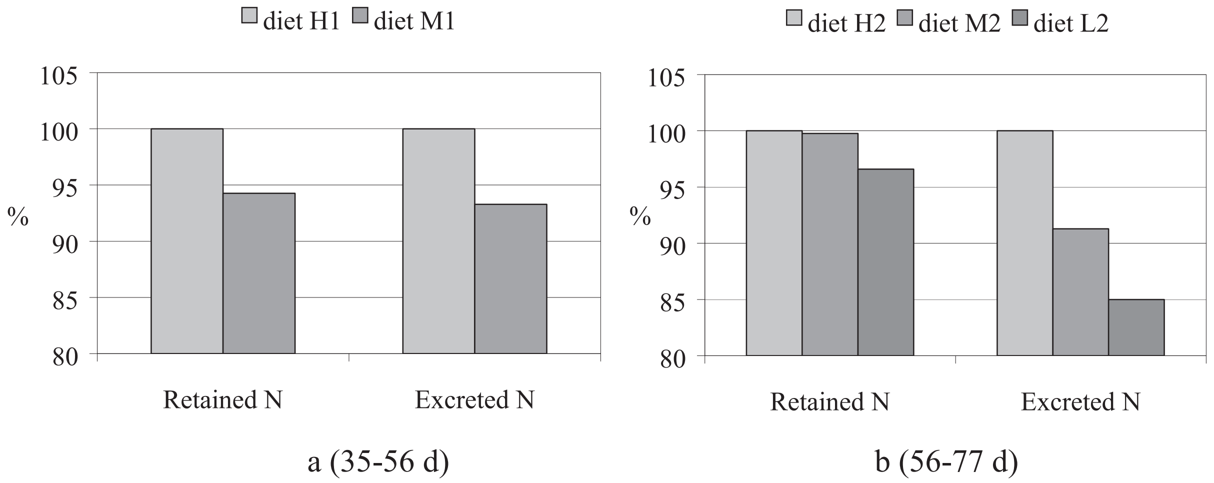
As regards meat quality, the lowest protein level of diet L2 induced a higher L* of the *biceps femoris* muscle (56.3) compared to diet H2 and M2 (54.8 on average; P=0.06).

Few literature is available on the effects of protein phase feeding on slaughter results.

XICCATO *et al.* (1993) did not found differences on carcass and meat composition when diets with different DP/DE ratio were fed in the fattening period.

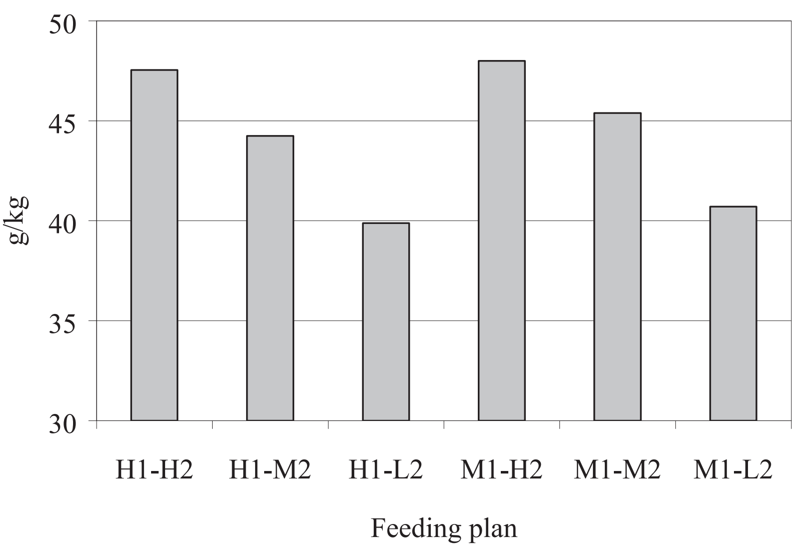
**Nitrogen excretion.** The reduction of protein level in the first period diminished nitrogen retention by 6% and nitrogen excretion by 7% (Fig. 1.a). This result was a clear sign of a deficit of dietary protein, which provoked lower body protein accretion, without affecting nitrogen retention efficiency. Nitrogen output was more influenced by the protein level reduction in the second period, during which N excretion of rabbits fed diets M2 decreased by about 9% in comparison with diet H2, without any reduction in nitrogen retention (Fig. 1.b).

**Figure 1**. Effect of dietary protein reduction on N retention and excretion (diets H1 and H2=100): a) first period (35 to 56 d); b) second period (56 to 77 d).




When diet L2 was fed, rabbits slightly reduced N retention (-3%) but strongly nitrogen excretion (-15%). These results indicated an excess of protein in the diet M2, whereas the diet L2 was probably below the protein requirement for the final growing period, as proved by the little decrease in growth performance and the lower muscular development.
The ratio between N excretion and live weight gain (g/kg) during the entire growing period may be used to compare the six feeding plans (Fig. 2). The combination of the diets H1-L2 permitted to minimize N excretion per kg of weight produced.

**Figure 2**. Effect of the feeding plans on excreted N/live weight gain ratio (g/kg) during the entire growing period (35 to 77 d).



The link between the dietary protein level and the nitrogen excretion was recently described (Maertens *et al.*, 1997; Maertens 1999). The present study outlined the importance of limiting dietary protein in the second period to reduce nitrogen excretion, since in this stage feed intake greatly increases and body protein retention rapidly decreases.

## CONCLUSIONS

The different protein requirements of rabbits in the first period of growth after weaning and in the last weeks before slaughtering were evidenced. During the first period, protein requirements were higher and a supply below 15.6% CP impaired growth performance with negative effects also in the second period. During this latter period, protein requirements appeared to be largely below the actual recommendations and dietary protein level of 13.1% did not compromise growth performance and feed efficiency. Really, the response of rabbits to decreasing dietary protein was a response to decreasing dietary AA apart from lysine and sulphur AA, which were supplemented above the minimum requirements. Rabbits AA requirements according to the different ages have still to be determined.

The effects of dietary protein reduction on carcass and meat quality were slight and could be summarised in the stimulation of fat deposition in the first period and in the reduction of carcass muscularity in the second one, when the lowest protein level was used.

The strong relationship between dietary nitrogen level and nitrogen excretion was confirmed and a predominant role was recognised to the last period of growth. In this period, the technical choice between medium (14-14.5%) or low (13-13.5%) dietary CP concentrations depends on the importance given either to the carcass quality or the nitrogen output impact.

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