NUTRITION OF LACTATING DOES

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INTRODUCTION

Ever since the last World Rabbit Congresses (Budapest, 1988; Corvallis, 1992) until the most recent Journées de la Recherche Cunicole en France (Paris, 1990; La Rochelle, 1994), the most important information on the nutritional requirements of lactating does involved the acquisition of more detailed knowledge of energy and protein metabolism, the utilisation of added-fat diets, and feeding modulation in closer accordance with the remating interval. Less attention has been given to mineral and vitamin nutrition; a few studies have considered the amino acid requirements, while others have dealt with the use of probiotics during the reproductive cycle.

On the whole, research regarding the diet of remating rabbits is slight at best, as shown by the few works dealing with the subject presented at the most recent international and Italian congresses since 1990 (Table 1). As may be seen, most research has been concentrated on the energy and protein diet and the role played by fibre. Research on vitamins has been centred primarily on Vitamin A and its toxicity at high dosage levels; very little research has been conducted on other nutrients and minerals.

Table 1 : Distribution of short papers on breeding rabbit nutrition presented at some recent international and Italian Congress

Congress	Energy protein/ fibre	Minerals	Vitamins	Probiotics	Foodstuffs	Total
5èmes J. Rech. Cun. (Paris, 1990)	2	1				3
9th A.S.P.A. Congr. (Roma, 1991)	4					4
5th WRS Congr. (Corvallis, 1992)	1		3	1	2	7
10th ASPA Congr. (Bologna, 1993)	2					2
6èmes J. Rech. Cun. (La Rochelle, 1994)	2					2
11th ASPA Congr. (Udine, 1995)	1					1

Despite the scarcity of scientific information, diets and feeding techniques of reproducing does have changed considerably over the years. The all-purpose diet suited to both growing rabbits and does was first substituted by reproduction diets that featured higher protein and energy levels for breeding females throughout the reproductive cycle, which were more recently replaced by diversified diets for various periods of reproductive activity: for young, pregnant, lactating, and simultaneously pregnant and lactating does. Despite the rapid development of reproductive activity in the rabbit and the overlapping of certain phases, the energy and protein metabolism and the utilisation of body reserves for milk synthesis and foetal growth vary and depend on the physiological state and breeding rhythm adopted, and require highly diversified strategies.

The digestive problems that commonly arise in weaning rabbits have obliged many breeders to adopt diets and feeding plans that give greater priority to the health of the litter at the expense of the nutritional conditions of the does. Therefore, in addition to the substitution of the reproduction diet with a specific diet for young rabbits after weaning, a new feeding system is now diffusing: the reproduction diet is given for the first 15-20 days of lactation and is then replaced until the next parturition by a weaning diet characterised by low or moderate protein and energy levels and higher fibre levels that are much more appropriate to the prevention of digestive disorders in the pups than the reduction of the energy deficit and depletion of body reserves in the does.

DIETARY ENERGY AND PROTEIN PARTITION AND BODY BALANCE

A factorial analysis of the data acquired in a number of research works conducted by our Department through the use of the comparative slaughter technique has permitted the identification of energy and protein requirements for maintenance and the estimation of the coefficients of utilisation of digestible energy (DE) and digestible protein (DP) for milk production (PARIGI BINI *et al.*, 1990b,c, 1991, 1992; PARIGI BINI and XICCATO, 1993; XICCATO *et al.*, 1992b). The coefficients of utilisation of the doe's body energy and protein for milk synthesis and foetal growth have also been calculated (Table 2).

Table 2 : Maintenance requirement and coefficients of utilisation of DE, DP and body energy and protein in breeding does (from Parigi Bini and Xiccato, 1993).

		Lactating[1, 2]	Lactating and pregnant[2, 3, 4]
Maintenance requirements:			
DE	kJ/d/kg $W^{0,75}$	430	468-470
DP	g/d/kg $W^{0,75}$	3,73	3,76-3,80
Coefficients of utilisation:			
- Foetal growth:			
DE		-	0,27-0,30
DP		-	0,42-0,46
- Milk production:			
DE		0,63	0,63
DP		0,77	0,76-0,80
Body energy		0,81	0,76
Body protein		0,59	0,60-0,61

(1)PARIGI BINI *et al.*, 1990b, (2)PARIGI BINI *et al.*, 1991.
(3)PARIGI BINI *et al.*, 1992. (4)XICCATO *et al.*, 1992b.

With the knowledge of these requirements and coefficients of utilisation, the protein and energy levels necessary for maintenance, the production of milk, and foetal growth can all be sufficiently estimated, together with the energy deficit and the consequent variation in body composition.

The energy and protein metabolism and nutritive requirements of reproducing does are influenced by different factors, such as physiological state, breeding rhythm, voluntary feed intake and diet composition.

Pregnancy

PARIGI BINI *et al.*, (1990b, 1991) have observed that primiparous does undergo wide variations in body composition, tissue deposition, and energy retention. During the early gestation period (0 to 21 days), the increase in live weight is similar to that of non-pregnant does. During the late period of pregnancy (21 to 30 days), the empty body weight is subject to a decrease as a result of protein and fat loss and the transfer of energy to the rapidly growing foetuses. At the same time, non-pregnant does continue to gain weight and retain body energy, primarily in the form of fat.

These results have been recently confirmed by research conducted at the University of Kaposvár (Hungary), where the variations in the body composition of primiparous does and non-pregnant does were compared through Computerised Tomography (CT) (MILISITS *et al.*, 1996). In this study, the total balance of body tissue showed a net loss in fat during the entire pregnancy that was equally distributed throughout the body's different fat deposits (intrascapular, perirenal, and pelvic fat).
The transfer of energy from the doe body to the foetuses results in an energy deficit that is especially concentrated in the last 10 days of pregnancy.

Lactation and simultaneous pregnancy

During the first lactation, the doe body is subjected to a pronounced reduction in energy reserves that follows the mobilisation of the fat deposits, while the body protein level remains virtually unchanged (PARIGI BINI *et al.*, 1990c, 1991, 1992; XICCATO *et al.*, 1992b, 1995). Unlike other species, this energy loss remains constant throughout lactation (PARIGI BINI *et al.*, 1990c) and no recovery is observed during the final phase due to the milk production, which remains high even after 25 to 30 days of lactation.

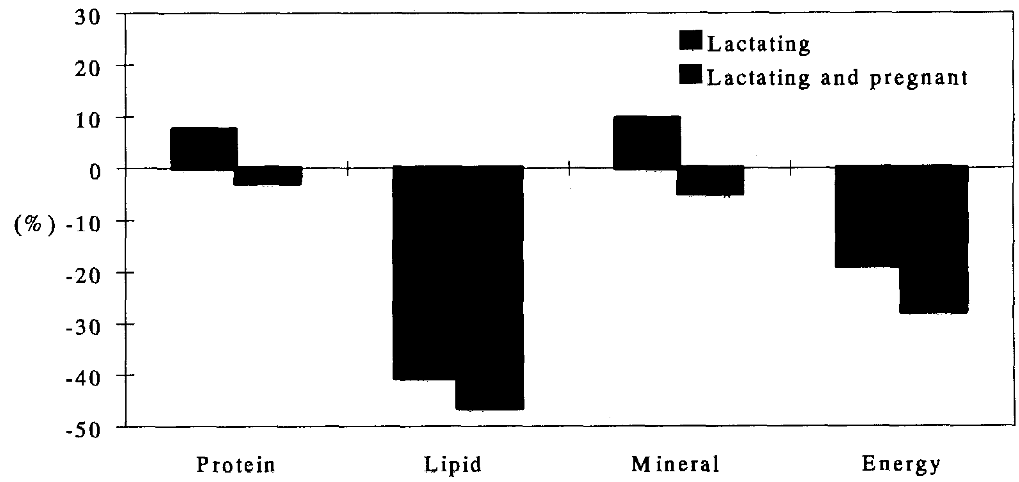
In the *post partum* (PP) mated does - and then concurrently pregnant and lactating - a rapid reduction in milk production is observed after 20 days of lactation (LEBAS, 1972; LEBAS *et al.*, 1984; MAERTENS and DE GROOTE, 1988a; PARIGI BINI *et al.*, 1991, 1992; XICCATO *et al.*, 1995). Nevertheless, all energy requirements remain high due to the rapid development of the foetuses and uterine tissues. The simultaneous condition of pregnancy accentuates these chemical modifications and is responsible for a further reduction in the fat content and body energy levels. The overlapping of pregnancy and lactation phases prevents the return to normal body conditions (FORTUN *et al.*, 1993) and increases the protein requirements in response to the elevated demand for protein by the foetuses and the rapid turnover in foetal protein (PARIGI BINI *et al.*, 1992; XICCATO *et al.*, 1992b, 1995).

Given that during lactation a reduction of empty body weight is also observed, the fat and energy balance is always negative in lactating does, and understandably worsens in those that are simultaneously lactating, with energy losses of around 25 to 30% of the initial body content and sometimes even higher. In addition, pregnant does also display significant losses in nitrogen and mineral levels (Figure 1).
The nutritional deficit provoked by lactation or feeding restriction also appears to be responsible for the decreased reproductive efficiency of lactating and concurrently pregnant does, and consequently a reduction in foetal development and viability (PARIGI BINI *et al.*, 1992; FORTUN *et al.*, 1993; FORTUN and LEBAS, 1994; FORTUN-LAMOTHE and BOLET, 1995).

Voluntary feed intake, digestive efficiency and dietary energy utilisation

Voluntary feed intake is the main limiting factor in the energy and material balance of lactating does because any intervention that stimulates feed ingestion tends to increase milk yield as well. This is true primarily for the females selected for milk production, or rather, the commercial "hybrid" does.

Figure 1. Material balance of rabbit does at the end of the first lactation (from Parigi Bini and Xiccato, 1993)



The appetite regulation in rabbits is mostly controlled by chemiostatic mechanism, for which reason the total quantity of energy ingested daily tends to be constant. Voluntary intake is proportional to metabolic weight (l.w.$^{0.75}$ or $W^{0.75}$). In growing rabbits, voluntary intake is about 950 to 1000 kJ/day/kg $W^{0.75}$ and the chemiostatic regulation appears only with a DE concentration of the diet higher than 9 to 9.5 MJ/kg (Partridge, 1986; Lebas, 1989; Santomá *et al.*, 1989), below which level a physical-type regulation is prevalent, and linked to the filling of the gut with the dietary material. Less is known about the voluntary intake of reproducing females, where the energy consumption (in terms of $W^{0.75}$) is lower in growing rabbits than in lactating females, which can ingest 1100 to 1300 kJ/day/kg $W^{0.75}$ of DE, with the lowest value recorded by primiparous females (MAERTENS and DE GROOTE, 1988a; LEBAS, 1989; PARIGI BINI *et al.*, 1990c, 1992; XICCATO *et al.*, 1992b, 1995). A second factor, which differentiates the voluntary intake of reproducing does in comparison with growing rabbits, is the energetic limit of chemiostatic regulation. Some research has demonstrated that an increase of DE concentration over the normal values of 10.5 to 11 MJ/kg permits a further increase in the daily energy intake of the lactating females (MAERTENS and DE GROOTE, 1988a; FRAGA *et al.*, 1989; CASTELLINI and BATTAGLINI, 1991; XICCATO *et al.*, 1995). In these animals the regulation limit probably varies by around

11 and 11.5 MJ/kg. This limit also depends on the dietary energy source and tends to be higher in added-fat diets than in the high-starch diets (FRAGA *et al.*, 1989; CASTELLINI and BATTAGLINI, 1991; XICCATO *et al.*, 1995).

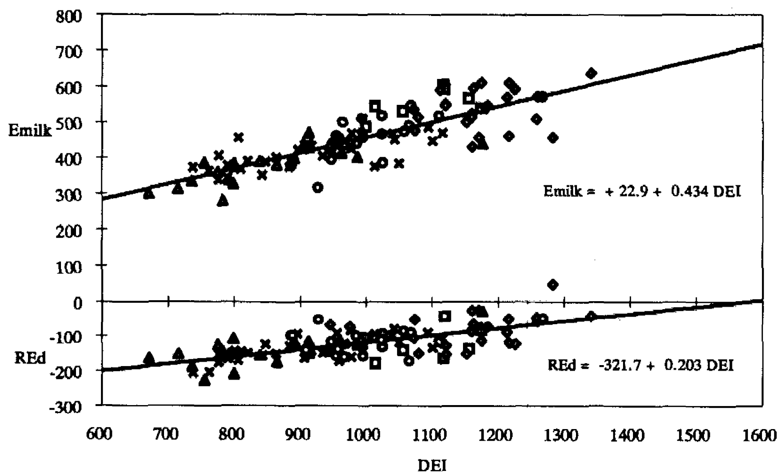
It is clear that the stimulation of energy intake is necessary to reduce the energy deficit in the lactating does. Moreover, as mentioned above, the higher dietary energy currently available to commercial does determines an increase in milk production, thereby cancelling, at least partially, the effect of increased DE intake. In fact, the genetic selection and the crossbreeding programs of the most common Italian and European hybrid lines pose the increase in litter size at birth and daily milk production as main objectives, delegating to secondary importance the goal of maintaining the body conditions and the length of the reproductive career of the females (DE ROCHAMBEAU, 1990). In this way, the limiting factor on doe productivity is not milk production but feed intake.

This hypothesis is demonstrated by the statistical analysis of the energy balance results achieved in 104 breeding does fed reproducing diets (17 to 18% CP and 10 to 11 MJ DE/kg) in different experiments performed by our Department. As shown in Figure 2, the DE intake (net of the requirements for simultaneous pregnancy) leads to a proportional increase in milk energy output. The production of milk energy (Emilk) and the energy retained in the doe's body (REd) are functions of the DE intake (DEI) in accordance with the following equations (all data are expressed as kJ/day/kg $W^{0.75}$):

(1)	Emilk	$= +22.9 + 0.434$ DEI	$r=0.826$	d.s.r.: 44.8
(2)	REd	$= -321.7 + 0.203$ DEI	$r=0.671$	d.s.r.: 34.0

The gross efficiency of utilisation of DEI is 0.434, or rather, each additional kJ of DE ingested determines an increase in milk energy production of 0.434 kJ. This efficiency is different from the net efficiency of utilisation of DEI for milk production, which is 0.63, as mentioned above (see Table 2), because a part of the available energy is used to reduce the energy deficit. This deficit can decrease by 0.203 kJ per each additional kJ of DEI. This trend, linear throughout the interval tested, shows a DEI at the energy equilibrium (REd=0) equal to 1585 kJ/day/kg $W^{0.75}$. A similar voluntary intake is very rare (on the average) in primiparous and secondiparous does, as shown in Figure 2, which shows that in all the experiments conducted in our Department, no females reached this intake and only one had a positive energy balance, due to her low milk production. At the equilibrium point, the energy milk output is 711 kJ/day/kg $W^{0.75}$, which corresponds to about 250 g/day of milk in a 4.25 kg rabbit, assuming a milk energy concentration of 8.3 to 8.5 MJ/kg (MAERTENS, 1992; PARIGI BINI *et al.*, 1992; XICCATO *et al.*, 1995).

Figure 2. Effect of DE intake (DEI) on energy milk production (Emilk) and energy retained in the doe body (REd) (data expressed in kJ/day/kg $W^{0.75}$)



The values estimated by the two equations coincide with the definition of "highly productive rabbit doe" given by Maertens (1992, 1995), or rather, a female capable of suckling 8 to 11 pups with a milk yield higher than 200 to 220 g/day and an average feed intake of 150 g/day/kg $W^{0.75}$ (i.e. 450 g/day in a 4.25 kg rabbit). Using a diet with 10.5 MJ/kg of DE, a doe like this must be able to ingest at least 1575 kJ/day/kg $W^{0.75}$ of DE.

From the above-mentioned equations, it is evident that any intervention performed to stimulate energy intake can only very rarely provide a substantial reduction of the body energy deficit. Sometimes, the contemporary increase in daily energy intake and milk production does not allow improvements in the doe's nutritional state (XICCATO *et al.*, 1995).

At any rate, we must consider that this situation occurs most frequently during the first lactation, whereas it becomes less important in the successive lactations. CASTELLINI and BATTAGLINI (1991), observed an increase of 22% in the feed intake from the first and the second lactation, 19% from the second and the third, and 7% from the third and the fourth, and reached a stable level after the fifth lactation. Similar results were observed by SIMPLICIO *et al.* (1988), while PARIGI BINI *et al.* (1989) and Battaglini and GRANDI (1991) found more limited variation in feed intake as a function of the parity order: 7 to 10% between the first and the second lactation and 3 to 5% between the second and the third, without observing any significant increment in the following lactations. Milk production also increases with parity order, but less markedly, and this permits better maintenance of the energy balance. Unfortunately, no recent research has been performed on pluriparous commercial rabbits for the purpose of obtaining greater information on the energy and material balance as a function of the parity order.

Another important factor that affects the attainment of body energy equilibrium is the reduction of the digestive and metabolic utilisation of the dietary energy that probably occurs with increased feed intake, which leads to faster digestive transit. With the equations above, we can hypothesise a worsening of the overall dietary energy efficiency. Table 3 provides the dietary energy partition in lactating rabbits that ingest 1000, 1250 and 1500 kJ/day/kg $W^{0.75}$.

Table 3 : Partition of DE intake and efficiency of utilisation of DE for milk production.

DEI	Emilk	REd	Emilk (REd)	Emilk (DEI)	DEm	DEmilk	Emilk (DEI)/Demilk
1000	457	-119	-96	361	430	570	0.633
1250	565	-68	-55	510	430	820	0.622
1500	674	-17	-14	660	430	1070	0.617

Legenda: DEI: Digestible energy intake; Emilk: milk energy; REd: Retained energy in the doe's body; Emilk(REd): Emilk derived from REd; Emilk(DEI): Emilk obtained from DEI; DEm: DE requirement for maintenance; DEmilk: DE utilised for milk production.

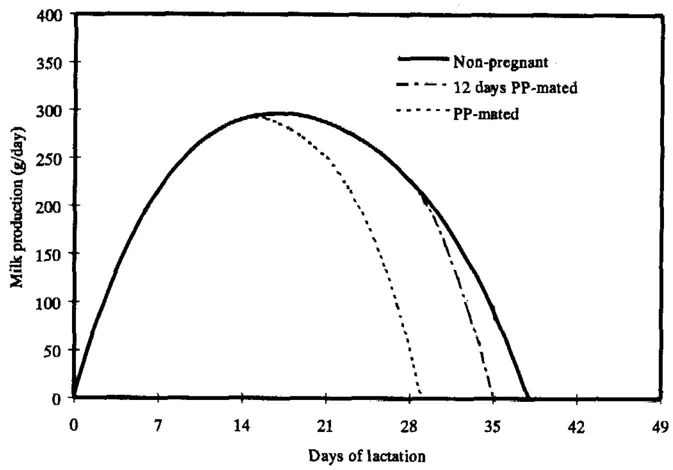
An intake of 1000 kJ corresponds to a milk production (Emilk) of 457 kJ and a body energy loss (REd) of -119 kJ. Assuming an efficiency of utilisation of body energy for milk production equal to 81% (see Table 2), the energy lost from the body allows a production of 96 kJ of milk. Therefore, the Emilk of dietary origin - i.e. Emilk(DEI) - is 361 kJ. After subtraction of the DE requirement for maintenance (DEm = 430 kJ), the quantity of DEI available for milk production (DEmilk) is equal to 570 kJ. As a consequence, the efficiency of utilisation of DE for milk production (Emilk(DEI)/DEmilk) is 0.633, in accordance with the previous estimates from our research (see Table 2). As the DE intake increases (at 1250 and 1500 kJ/day/kg $W^{0.75}$), a worsening of energy efficiency is estimated (0.622 and 0.617, respectively).

It is not possible to be sure if the reduction in the efficiency of the utilisation of dietary energy is due to a lower metabolic efficiency or, more probably, to a decrease of the energy value of the feed ingested in higher amounts and therefore less digestible. In this regard, de Blas *et al.* (1995) found lower DM and GE digestibilities (-0.6 to -0.7%; Prob. = 0.08) in lactating does in comparison with non-lactating females which ingested less food. These results agree with our previous data collected on young and adult rabbits fed *ad libitum* or kept on restricted feeding (XICCATO *et al.*, 1992a).

Breeding rhythm

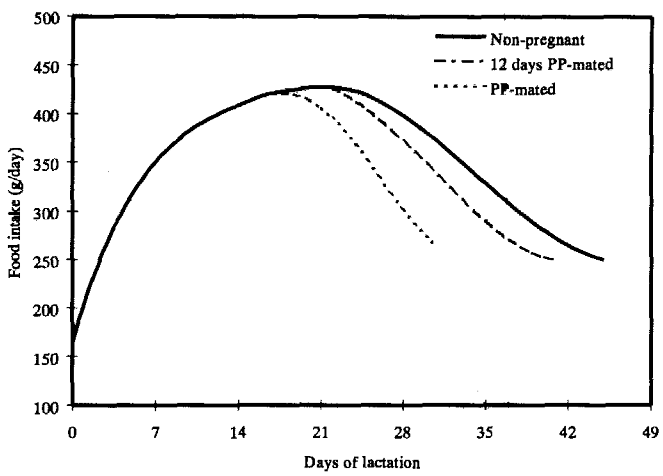
In addition to increasing the feed intake by changing the composition of the diet, a second method of improving the energy balance in lactating does consists in adopting the most appropriate reproductive rhythm. It affects both milk production and feed intake (Figure 3 and 4).

Figure 3. Effect of breeding rhythm on milk production



Remating immediately or within a few days after parturition (PP) results in the almost complete overlapping of the lactation and pregnancy periods, thereby provoking the worsening of the energy balance and depletion of protein reserves in the does described above. Moreover, lactations are repeated with such frequency and without any rest as to preclude recovery and diminish energy reserves even further, and produce negative repercussions on fertility and reproductive performance. The lack of pregnancy is the doe's only defence in such cases of energy deficiency: a longer interval between the end of one lactation and the beginning of another permits the restoration of body energy reserves and the adequate response to the next lactational requirements.

Figure 4. Effect of breeding rhythm on food intake

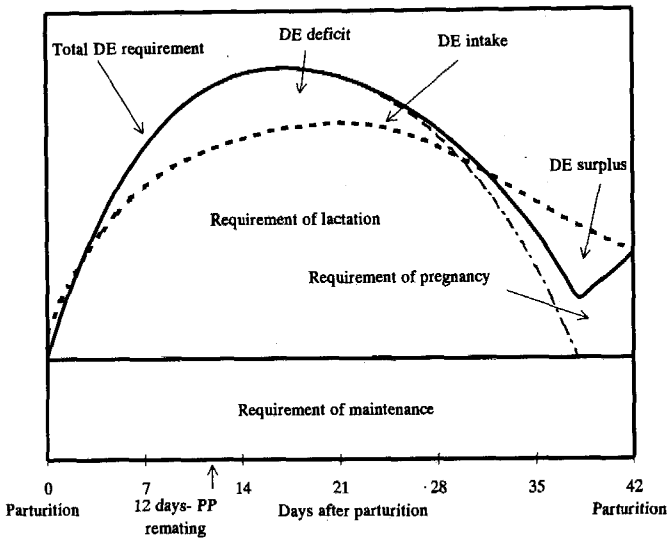


Various authors have studied the correlation between reproductive rhythm and diet (MENDEZ *et al.*, 1986; FRAGA *et al.*, 1989; CERVERA *et al.*, 1993), and most have observed an increase in milk production and an improvement in reproductive performance when semi-intensive breeding rhythms were adopted (remating 9 to 15 days PP), while the diet was found to have only a marginal effect on reproduction.

In practical terms, most Italian breeders have now abandoned the excessively intensive PP reproductive rhythm characterised by low fertility, reduced litter sizes, and higher doe replacement rate in favour of a rhythm, that although still considered intensive, permits adequate recovery of the doe's body energy loss. Remating 10 to 12 days PP (Figure 5), which amounts to a theoretical 42-day interval between parturitions, or rather, remating every 6 weeks has been found to be the ideal compromise between economical convenience and the physiological and metabolic requirements of the does (MAERTENS, 1992; XICCATO, 1993). This rebreeding schedule permits programmed mating and technical operations, encourages the maintenance of good maternal body conditions through the *ad libitum* food administration, improves fertility and litter size, and permits weaning to be performed at a later date (32 to 35 days).

Widespread opinion also holds that in addition to reducing reproductive performance, a more extensive remating interval (21 to 28 days PP or even post-weaning) requires the use of restricted feeding through rationing in order to prevent the excessive fattening of the does and the negative consequences on fertility and prolificacy that usually ensue (MAERTENS, 1992). A technical choice such as this should be motivated only by particular management necessities (e.g. the "single-cycled" or "bande unique" system) or the use of unimproved breeds and non-industrial production systems.

Figure 5. Changes in energy balance and energy intake during lactation (Xiccato, 1993)



In contrast with this opinion, new research soon to be presented here (PARIGI BINI *et al.*, 1996) demonstrates that the 12-day PP remating of primiparous does not permit sufficient recovery of the energy deficit, which remains rather high (-26% of the initial energy level) and not very lower than the deficit recorded during the lactation period (-32%). More surprising, however, is the fact that not even a longer remating interval (28-day PP) permits the recovery of the energy deficit caused by lactation, which remains at -16%. While demonstrating the positive effect of more extensive remating intervals, this result is undoubtedly caused by the natural decrease in the does' food intake at the end of lactation, which makes return to the original energy reserves even longer.

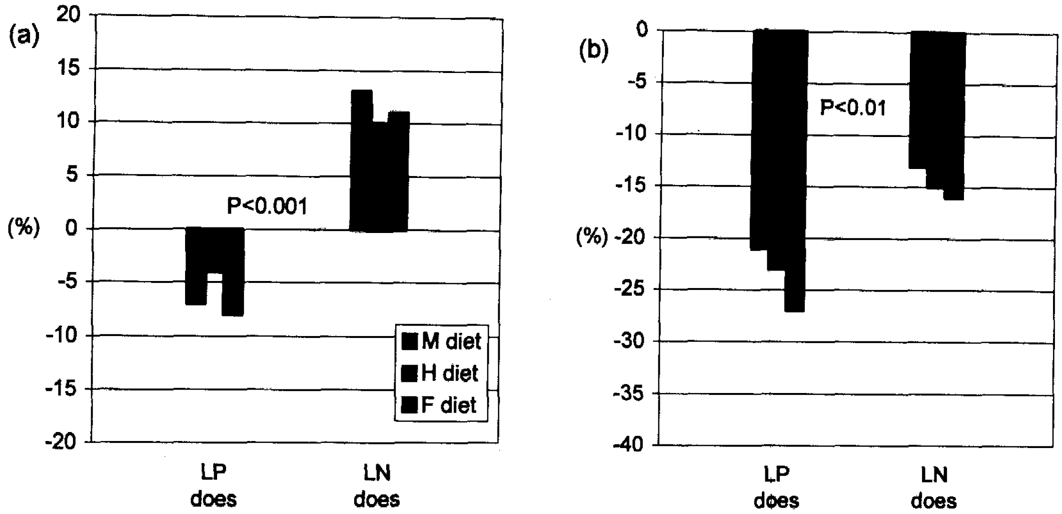
Another aspect that should be considered in greater detail and given more priority in further research and practical application is the correlation between the breeding rhythm and the diet composition. In the above-mentioned study, an added-fat diet worsened the energy balance in does remated 12 days PP (-30% vs. -24% of the normal starch-based diet), while permitting a faster restoration of initial body conditions in does submitted to a 28-day PP remating (-14% vs. -17%).

Effect of added-fat diet

Rabbit commercial diets usually contains 2 to 3% crude fat. These levels are rather low due to the scarce contribution of the raw materials of vegetal origin usually utilised in formulation (alfalfa, bran, cereal and protein meal). The addition of vegetal or animal fats in moderate quantities (3 to 5%) seems to provide good practical results in doe nutrition because it permits the energy concentration to be increased until 11 to 11.5 MJ/kg without decreasing the fibre content or excessively raising the starch concentration. In addition to providing energy, fat also usually leads to an increase in the digestibility of the other nutritional components in the diet and induces an increase in the overall energy intake, with positive effects on the doe's body conditions and the litter weight at weaning (PARTRIDGE, 1986; FRAGA *et al.*, 1989). In Italy, CASTELLINI and BATTAGLINI (1991) have observed higher DE consumption in does fed with full-soybean diets.
Two studies carried out by our Department (XICCATO *et al.*, 1995, PARIGI-BINI *et al.*, 1996) compared diets with different energy contents with and without the addition of animal fat. Similar research has been performed by other authors (BARRETO and DE BLAS, 1993; CERVERA *et al.*, 1993; FORTUN and LEBAS, 1994). Generally speaking, the addition of fat increased the diet's energy concentration and daily DE intake while reducing total food consumption. The higher energy intake always lead to a greater production of milk, to the advantage of the litter growth, but in general did not appear to significantly reduce the energy deficit in the does (Figure 6). CERVERA *et al.* (1993) observed a greater energy intake in does fed a diet containing 35 g/kg of pork lard (11.3 MJ DE/kg) compared to those without fat and lower in DE content (8.6 to 10.1 MJ/kg). Does

fed in this way provided litters with heavier weight at birth, at 21 days and 28 days of age (P<0.001), while demonstrating variations in live weight similar to other groups.

Figure 6 : Balance of (a) protein and (b) energy in empty body of does given different diets (M: moderate energy diet; H: high starch diet; F: added-fat diet (from XICCATO *et al.*, 1995).



In consequence, the only immediate advantage to be derived from the use of added-fat diets is the increase in the quantity of milk available for the litter and the greater weight at weaning as a result. In reality, however, a number of negative aspects linked to high-energy content diets must also be indicated. As observed by XICCATO *et al.* (1995), lactating pregnant does fed with high-energy diets (provided both by starch and fat) produced litters with a lower number of pups born alive than does fed with medium-energy diets. In addition, although heavier, the new-born pups from does fed high-energy diets presented lower body energy and lipid contents. Although statistically not significant, this tendency must not be underestimated because it confirms our previous findings (PARIGI BINI *et al.*, 1992; XICCATO *et al.*, 1992b), on one hand, and those of VIUDES-DE-CASTRO *et al.* (1991), on the other. These authors observed a significantly lower number of pups born alive (-2.7 per litter) in the second parturitions of does fed high-energy diets containing 3.1% animal fat. On the contrary, BARRETO and DE BLAS (1993) observed an improvement in the fertility of does fed added-fat diets, while Fortun and LEBAS (1994) failed to observe any significant difference in the reproductive performance of lactating pregnant does fed diets that were similar to those utilised in our research.

The role of starch and fibre

Fibre, in terms of both quality and quantity, is probably the nutrient that has been subjected to most study after energy, especially in relation to its unanimously recognised influence on the health state and digestive efficiency of the rabbit. This factor has been particularly studied in weaning rabbits over the past few years due to the close connection between dietary fibre and the appearance of digestive disorders. In reproducing rabbits, the problem is primarily associated with the dietary energy level, because the need to increase the DE content by primarily increasing its percentage of starch produces the risk of lowering the fibre content to a level below the limit considered compatible with the health state of the doe and the weaning litter.

Increased fibre content generally leads to a decrease in the DE content of the diet (WISEMAN *et al.*, 1992) to the point that a large number of equations have been proposed for the estimation of feed energy value starting from the content of crude fibre or different fibre fractions (NDF, ADF, ADL) (see reviews by PARIGI BINI, 1988; SANTOMA *et al.*, 1989; MAERTENS, 1992; XICCATO, 1993).

This does not mean that fibre has a negative or even anti-nutritional effect, but merely that it provides a smaller nutritional contribution than other components due primarily to its lower digestibility. In a conventional and complete rabbit feed, crude fibre digestibility varies from 15 to 20%. The digestibility of the crude fibre of various raw materials varies widely, with minimum values (5 to 10%) observed for rough forages and by-products (hay, straw, grape marc), medium values (10 to 20%) for alfalfa meal, a few cereal (barley, oats) and their by-products (wheat bran), and higher values (20 to 40%) for corn and soybean. Lastly, beet and citrus fruit pulp offer fibre that is particularly digestible (40 to 70%) (MAERTENS *et al.*, 1990; FRAGA *et al.*, 1991;

VILLAMIDE and DE BLAS, 1991; DE BLAS, 1992). In reality, it is evident that the digestibility of crude fibre depends upon its composition, and it has been shown that the fibre of various food sources is very digestible when it is composed primarily of pectin and hemicellulose (e.g. beet pulp), intermediately digestible when composed of high percentages of cellulose (e.g. alfalfa meal) and not very digestible when the ADL content is high (e.g. grape marc) (DE BLAS, 1992). These observations lead us to replace the crude fibre content with various fibre fractions in the equations used to estimate the diet's energy value. In any case however, these equations have rarely been more precise than those based on crude fibre and are often closely linked to the presence of specific raw materials in the diet (PARIGI BINI, 1988; SANTOMA *et al.*, 1989; MAERTENS, 1992; XICCATO, 1993).

The need to identify the food sources capable of contributing the quantity of fibre necessary for correct digestive functionality without reducing the dietary energy supplied to the does has lead to the development of a line of study that has been given particular attention by Spanish research workers.

In a recent study on lactating pregnant does, FERNANDEZ *et al.* (1995) investigated the effect of two isoenergetic diets with widely differing crude fibre (12.1 vs. 19% DM) and ADF (15.3 vs. 24.1% DM) concentrations. The two diets also differed slightly in DP content (13.8 vs. 15.2% DM). Although no differences were observed in the litter size and weight, the low-fibre diet increased milk production and reduced the pup mortality, especially during the first 21 days of lactation. According to the authors, the increased milk production was accompanied by a lower average food (and therefore energy) intake that can only be explained by a difference in terms of the net energy provided by the diets (equivalent to 6 to 11%). This might be ascribed to the greater energy losses occurred during the digestion (e.g. methane) or metabolism (e.g. heat increment) of the diet that was richer in fibre and digestible protein. Even if the doe's body composition data required to perform a complete energy balance was not available, the study suggests that the experimental measurement of the apparent energy digestibility in growing rabbits (see EGRAN method, PEREZ *et al.*, 1995) is not the correct way to estimate the energy value of reproduction diets characterised by marked differences in fibre (and protein) content. Cases like these would require the development of different energy systems based on metabolisable (MAERTENS, 1992) or net energy systems or the introduction of various chemical composition correction factors.

Another interesting study by DE BLAS *et al.* (1995) compared 5 diets characterised by decreasing starch contents (from 26.6% to 13% DM) and increasing crude fibre, NDF (from 31.2% to 41.2%) and crude fat (from 2.3% to 5.7%) concentrations. The variations in chemical composition were obtained primarily by replacing the starch source (barley) with NDF (alfalfa and wheat bran) and fat (pork lard) sources. The results of the administration of these diets to does are provided in Table 4.

Table 4 : Effect of starch and NDF contents on the diet digestibility and doe performance (from DE BLAS *et al.*, 1995).

Diet		1	2	3	4	5	Probability[1]	
Starch		26.6	24.6	19.0	16.8	13.0		
NDF		31.2	33.4	36.0	38.4	41.2	L	Q
Digestibility coefficients[2]:								
DM	%	65.9	66.3	64.5	63.2	61.6	<0.001	
GE	%	66.2	66.6	64.9	64.0	62.7	<0.001	
Starch	%	98.3	97.9	97.4	97.6	95.6	<0.001	
NDF	%	29.4	34.1	35.1	39.0	41.6	<0.001	
Does and litter performance:								
Total milk production	kg	5.83	5.82	6.06	5.94	5.73		0.15
Final weight of does	kg	4.09	3.97	3.98	3.99	3.92	0.09	
Annual replacement rate	%	75	62	66	47	59	0.07	
Does feed intake (0 to 30 d)	kg/d	0.351	0.344	0.349	0.349	0.338		
Litter feed intake (21 to 30 d)	kg/d	0.202	0.235	0.186	0.163	0.157	<0.001	
Litter weight at 21 days	kg	2.88	2.94	3.06	2.91	2.88		0.15
Litter weight at weaning	kg	4.93	5.19	5.29	4.92	4.76		0.07
Pup mortality (0 to 21 d)	%	7.08	8.88	7.16	7.91	7.07		
Pup mortality (21 to 30 d)	%	1.20	1.51	0.73	0.82	1.30		0.10
Weaning weight/feed intake (does+litter)		0.335	0.338	0.354	0.340	0.325		0.02

(1) Statistical significance of the linear (L) or quadratic (Q) response to dietary starch content ;
(2) Determined on growing and adult rabbits.

With the progressive decrease in the starch content and the proportional increase in NDF, the digestibility of DM, energy and starch decreases directly, while that of NDF increases in agreement with the observations of PARIGI BINI *et al.* (1990a) on growing rabbits. The intermediate diet containing 19% starch and 36% NDF produced better productive and reproductive performance (significant quadratic effect of the starch level). This diet also produced better nutritional efficiency in terms of weight of weaned pup per kg of total feed ingested (doe + litter). The doe weight of the doe at weaning, on the other hand, increased linearly with the starch content, but this also lead to a corresponding raising in the annual doe replacement rate. The most interesting result observed by these authors was that the starch and fibre contents most appropriate to the does (19% and 36%) were most probably those that guaranteed the best growth and health of the litter during weaning (CARABAÑO, 1995). These results induce careful thought on the suitability of continually reducing the energy level and increasing the fibre content in the weaning diets which are often given to both does and litters starting from 15 to 20 days after lactation.

Feeding of young rabbit does

In the first part of this paper, we emphasised the importance of beginning the mating career with does capable of withstanding the rapid and intense metabolic process of lactation and pregnancy and the great variation of body composition caused by the utilisation of energy body reserves. These does must have already developed a high feed intake ability in order to allow the inevitable energy and material deficit to be recovered.
Up until now, no definitive experimental results have been made available on the effect of the diet and feeding plan adopted during the growth of young rabbit females in regard to their subsequent body condition, voluntary intake and reproductive performance. The feeding plan proposed by MAERTENS (1992) consisted in administrating to the young does a reproduction diet in a restricted amount (35 g/kg live weight) until 17 to 18 weeks of age, followed by 4 days of flushing before the first mating. In the case of *ad libitum* feeding, this author suggested the use of a diet for fattening rabbits that is usually less concentrated in energy than the diet prescribed for lactating does.

The Padova and Perugia research groups performed a common research to study energy metabolism and reproductive physiology and improve the rearing and feeding techniques of young rabbit does. They compared different diets and administration methods in order to encourage the morphologic and sexual development of the rabbits, promote reproductive and mammary tissue growth, and stimulate voluntary feed intake, without causing excessive fattening of the animals. The first results, showed a limited effect of the diet administrated during the growing period on the subsequent pregnancy and lactation (PARIGI BINI *et al.*, 1995). Nevertheless, the body energy balance at the end of the first lactation of does fed with a specific diet low in DE concentration and rich in fibre was less negative (-36% of the initial energy content) than the balance of does fed with a conventional reproduction diet higher in energy (-41%).

Above and beyond these first experimental results - which should be evaluated with attention and confirmed by other studies - the feeding of the young doe should be based on a diet containing a moderate energy level that is rich in fibre but also well provided with protein. This diet must be administered *ad libitum* throughout most of the growing period until the first mating, in order to allow good somatic development (75 to 80% of adult live weight) and increase the doe intake ability during her subsequent reproductive career.

PROTEIN AND AMINO ACID NUTRITION

DP to DE ratio and protein requirements

In practice, the protein levels recommended for remating does range from 17.5% and 19% as crude protein (CP) and 12.5% to 13.8% as digestible protein (DP), which in normal feed for does are equivalent to a ratio of 11.5 to 12.5 g DP/MJ DE. The higher values are recommended for does subjected to intensive breeding rhythms (LEBAS, 1989; SANTOMA *et al.*, 1989; MAERTENS, 1992; XICCATO, 1993).
DP to DE ratios lower than those recommended above lead to a significant decrease in milk production and reproductive performance in particular (PARTRIDGE and ALLAN, 1982; SANCHEZ *et al.*, 1985; MENDEZ *et al.*, 1986; SANTOMA *et al.*, 1989; LEBAS, 1989).

For this reason, abundant protein levels in the reproduction diets have always been encouraged. Protein excess, however can lead to productive and sanitary problems. BARGE *et al.* (1991) observed that a diet with an unbalanced DP to DE ratio (14.3 g DP/MJ DE) induced inefficient regulation in the energy voluntary intake of primiparous does and lead to insufficient food intake and consequently negative effects on the sukling litters and doe body conditions. The same diet caused no negative effects, however, on pluriparous does, who proved capable of ingesting food quantities similar to does receiving diets balanced in protein. In terms of practical rationing, Jarrin *et al.*, (1994) obtained positive results with the adoption of a "all-purpose" diet with lower energy (10.4 MJ DE/kg) and CP (17%) contents, but the same CP to DE ratio (16.2 to 16.5 g CP/MJ DE) than those commonly used for does. This diet also reduced the mortality rate at weaning and the annual doe replacement rate (from 106% to 83%). It has been impossible to establish, however, if the positive effect of this diet can be ascribed to the lower protein level or the slightly higher fibre level (15.8% vs. 14.1%).

In pregnant lactating does, a reduction of the DP to DE ratio frequently produces a decrease in the reproductive performance, as shown by XICCATO *et al.* (1992b), who observed a decrease in the weight and size of litters delivered by does remated 4 days PP and fed with a moderate DP to DE ratio (11.2 g DP/MJ DE) when compared to rabbits that received higher protein contents (12.5 g DP/MJ DE). The simultaneous occurrence of pregnancy and lactation also tended to determine a negative protein balance, whereas this balance proved to be slightly positive in does that were lactating only. This is due to the specific protein requirements of the foetuses and the intense foetal protein turnover, which was demonstrated to be 5 times higher than that of maternal tissue, as observed in sheep by YOUNG (1979).

In three studies conducted by our Department already mentioned above, the factorial approach was also used to estimate the DP requirements for maintenance (3.73 to 3.80 g/day/kg $W^{0.75}$) and the efficiency of utilisation of dietary protein (0.76 to 0.80) and body protein (0.59 to 0.61) for milk protein synthesis (Table 2). The efficiency of utilisation of DP for foetal protein growth was demonstrated to be rather low (0.42 to 0.46), and somewhat lower than that observed in growing rabbits (DE BLAS *et al.*, 1985; PARIGI BINI and XICCATO, 1986; NIZZA *et al.*, 1995), probably due to the extremely rapid foetal protein turnover mentioned above.

Amino acid requirements

The precise amino acid (aa) requirement for reproducing does has not yet been clearly established, although various tables have been proposed (Table 5). The aa levels normally utilised are those provide by LEBAS (1989) and SANTOMA *et al.* (1989), and partially revised by MAERTENS (1992). Recent literature on rabbit aa requirements is very scarce and limited to a few aa (lysine, sulphur-containing aa), and even more so for does.

In any case, the knowledge in the field does not appear to be growing, given that almost all the requirements reflect those proposed by INRA (1984) and agree that does have a greater need for sulphur-containing amino acids and lysine than growing rabbits (MAERTENS and DE GROOTE, 1988; BERCHICHE and LEBAS, 1994; TABOADA *et al.*, 1994). Among the essential aa, methionine (and/or cystine) is the most limiting, immediately followed by lysine. While the difference between the optimum level and the toxic level is high for lysine and arginine, it is lower for sulphur-containing aa (COLIN, 1978, cited by LEBAS, 1989) and the tangible risk exists of reaching levels of acute toxicity in case of errors regarding the inclusion and mixture of synthetic methionine.

The aa value of the various raw materials utilised in rabbit diets depends on whether this value is expressed as "total" or "digestible" aa, as shown by GARCIA *et al.* (1995). In an experiment conducted to study the optimum level of lysine in high productive does, TABOADA *et al.* (1994) emphasised the importance of making the distinction between total lysine and digestible lysine contents: this difference assumes all the more importance when synthetic lysine (L-lysine HCl), which is more easily digestible than normal lysine, is used. The levels recommended by the authors (for diets of 10.7 MJ DE/kg) were 0.52% digestible lysine (0.68% total lysine) for the maximum reproductive performance and 0.64% digestible lysine (0.80% total lysine) for maximum milk production.

As far as the other essential aa are concerned, TABOADA *et al.* (1995) found that a minimum level of 0.54% of total sulphur-containing aa (0.40% of digestible sulphur-containing aa) was required to obtain adequate productivity in remating rabbits and growing rabbits, while a higher level (0.62% of total sulphur-containing aa) permitted a 6 to 8% increase in the milk production, reduced the interval between parturitions, and improved feed utilisation efficiency.

Table 5 : Amino acid requirements (%) in lactating does

	INRA[1] (1984)	AEC[1] (1988)	COLIN[1] (1988)	LEBAS (1989)	MAERTENS (1995)
Methionine+ cystine	0.60	0.65	0.80	0.55	>0.62
Lysine	0.75	0.75	0.73	0.90	>0.85
Arginine	0.80	0.90	0.88	0.80	>0.80
Threonine	0.70	0.65	-	0.70	>0.70
Tryptophan	0.22	0.22	-	0.15	>0.15
Valine	0.85	0.85	-	0.85	>0.85
Leucine	1.25	1.30	-	1.25	>1.25
Isoleucine	0.70	0.65	--	0.70	>0.70
Histidine	0.43	0.40	--	0.43	>0.43
Fenylalanine+ tyrosine	1.40	1.30	--	1.40	>1.40
DE (MJ/kg)	10.95	10.45	10.67	10.90	>10.50

[1] From SANTOMA *et al.*, 1989.

VITAMIN AND MINERAL REQUIREMENTS AND FEED ADDITIVES

Vitamins

The addition of Vitamin A to the diet is essential for both growth and reproduction, but at high dosages this substance reduces reproductive efficiency and produces teratogenic effects, with the decrease of foetal growth, bone abnormalities, early foetal resorption, late abortions, reduced litter size, increased natal and post-natal mortality, and hydrocephalus, etc. (CHEEKE 1987; CHEEKE *et al.*, 1984; MOGHADDAM *et al.*, 1987; LEBAS, 1989). After analysing the negative effect of excessive Vitamin A intake on White New Zealand rabbits, DEEB *et al.* (1992) hypothesised that under natural conditions the rabbit is able to protect itself against ß-carotene excess by decreasing the conversion efficiency on Vitamin A, but unable to self-defend against an excess of Vitamin A added to the diet in the form of retinol (esters, acetate, or retinol palmitate). An excess of these substances in the liver inhibits the synthesis of the RBP (retinol binding protein) that regulates the mobilisation and release of retinol, thereby permitting the toxic forms of Vitamin A to reach the foetal tissues during the critical differentiation periods. The recommended level of Vitamin A - equivalent to 10,000 IU/kg (LEBAS, 1989) - is in reality, quite far from the level of retinol required to produce toxic effects in reproduction (approx. 90,000 IU/kg). At any rate, in the opinion of DEEB *et al.* (1992), the need for Vitamin A should be satisfied with ß-carotene, which the rabbit absorbs through an efficient regulation process. Regardless of its transformation into Vitamin A, a specific vitamin action has long been hypothesised for ß-carotene (PARIGI BINI, 1983; LEBAS, 1989), but not definitely confirmed by experimental results.

It has been demonstrated that the plasma level of Vitamin A is influenced by the physiological state of the doe, and assumes increasingly greater values at parturition than during pregnancy and lactation, while the accumulation of Vitamin A during the final phase of pregnancy and the subsequent release of colostrum has also been hypothesised (ISMAIL *et al.*, 1992a). These authors have shown that the addition of Vitamins C or E, or substances like ethoxyquin permits a reduction in the negative effects caused by Vitamin A excess. As known, Vitamin E is important for fertility and reproductive functions, in addition to preventing tissue peroxidation and muscular dystrophy. It also increases resistance to disease and reinforces the immunological response (REDDY *et al.*, 1987). The level of Vitamin C, that is normally sufficient in low quantities under normal breeding conditions, must be increased under stress conditions (McDowel, 1989). Ethoxyquin is normally added to the diet because of its natural anti-oxidation effect, which protects Vitamin A from degradation (ISENSTEIN, 1970). The work performed by ISMAIL *et al.* (1992a) on does fed diets with an excess of Vitamin A (retinol palmitate given orally in 25,000 IU/animal/day dosage) demonstrated that the addition of Vitamin C (50 mg/animal/day) or Vitamin E (50 mg/animal/day) or ethoxyquin (25 mg/animal/day) reduced the frequency of reproductive dysfunctions. Vitamin C in particular, but also Vitamin E, provided beneficial effects in the reduction of cases of foetal resorption, hydrocephalus, and perinatal and post-weaning mortality, while ethoxyquin showed beneficial effects only in the reduction of foetal resorption. The negative effects caused by an excess of Vitamin A disappeared completely 12 weeks after administration.

The supplementation of Vitamins C and E also improves the reproductive response of rabbits subjected to stress conditions, as shown in an experiment conducted in Egypt (at temperatures of more than 30°C during the day and 20°C during the night). The addition of the two vitamins above reduced post-natal mortality and made a negligible increase in the litter size and weight (ISMAIL *et al.*, 1992b).

The ideal levels of Vitamin D in rabbits have not yet been established with precision, but in the opinion of LEBAS (1989) are equivalent to 1000 IU/kg, regardless of the category of animal involved. Vitamin excesses of between 3,250 IU and 13,200 IU/kg lead to the mineralization of the soft tissues, with the presence of cases of anorexia, weight loss, and dehydration (LÖLIGER and VOGT, 1980; ZIMMERMAN, 1990) along with increased foetal mortality (KUBOTA *et al.*, 1982). Tissue calcification (aorta, kidneys, etc.) was found to be worsened by the presence of an excess of calcium in the diet (LEBAS, 1989).

As far as hydrosoluble vitamins in general are concerned, the capacity of the rabbit's intestinal flora to create important quantities of vitamins (Groups B, K, C, etc.) and their availability through ciecotrophy must also be remembered. Apart from the beneficial effect of the addition of Vitamin C to the diet mentioned above, no other research into the effects and requirements for hydrosoluble vitamins in current doe breeding conditions has been conducted in recent years.
The levels normally utilised for vitamin supplementation in the diet are those provided by LEBAS (1989).

Macrominerals

As already mentioned for vitamins, in comparison with the experiments performed on other aspects of nutrition and feeding, very little research into the requirements and utilisation of minerals in rabbits has been performed in recent years. Generally speaking, the integration of minerals into the diet is performed by adopting the levels prescribed by LEBAS (1989), which have been utilised in large part by XICCATO (1993) and MAERTENS (1995).

Lactating does have a higher need for certain minerals (Ca, P, Fe, Zn) than growing rabbits or non-lactating does. These mineral requirements are usually covered by the commercial diets normally used during lactation, and the mineral balance is substantially even or slightly positive by the end of lactation (see Figure 1) (PARIGI BINI and XICCATO, 1993; XICCATO *et al.*, 1995). In the event of the total overlapping of lactation and pregnancy however, a slight mineral deficit can arise. In any case, it is the loss of high quantities of Ca (1.5 to 2 g/day) and P (0.6 to 1 g/day) through the milk that accounts for the elevated need for minerals in lactating does (LEBAS *et al.*, 1971; LEBAS, 1989). Excesses in these substances as well can induce significant alterations in both the fertility and prolificacy of the does (LEBAS and JOUGLAR, 1984) and must be considered negative due to interaction with other mineral absorption and the environmental impact (e.g. P, heavy metals).

Calcium (Ca), and its interaction with the absorption and metabolism of other minerals such as phosphorous (P) and magnesium (Mg), is one of the minerals that has been studied most. Unlike other species, the level of Ca in rabbit plasma is not regulated through osmosis but varies in respect to the amount of Ca contained in the diet, and the absorption rate is not affected by metabolic demand (CHEEKE, 1987). In reality, a higher percentage of Ca in the diet permits greater Ca and Mg absorption and reduces P utilisation (a greater presence of Ca in the plasma, aorta, and kidney is stimulated by the presence of Vitamin D) (KAMPHEUS, 1991). Ca absorption depends primarily on the different degrees of apparent digestibility of the raw materials, varying from 81% for calcium carbonate to 53 to 54% for other inorganic (calcium diphosphate, calcium ossalate) or organic sources (alfalfa, clover) (CHEEKE *et al.*, 1985, LEBAS, 1989). Unlike P, the utilisation of Ca is also influenced by extremes in temperature (Aguilera *et al.*, 1987). Lastly, the dietary Ca content is important for the potential interaction of this element with the toxic action of heavy metals such as the reinforcement of the negative effect of cadmium on L-threonine absorption (MESONERO *et al.*, 1995).

As far as P is concerned, in an experiment performed on does fed diets containing different levels of P (0.45% to 0.76%) and a similar Ca concentration (1.2%), LEBAS and JOUGLAR (1990) did not record any significant influence of the P level on reproductive performance (number of pups born alive, number of pups weaned, etc.) or on the live weights of the females. This diet significantly affected weight at weaning, which proved to be lowest where P concentrations were highest, but provided no important influence on average daily weight growth or pup mortality. These results induced MAERTENS (1995) to reduce the recommend levels of P from 0.70% (LEBAS, 1989) to 0.55%.

In any case, the choice of both P and Ca levels should also consider the breeding rhythm and therefore slightly higher levels of the two elements are advised (1.3% for Ca and 0.6% for P) when intensive rebreeding systems are used (remating interval shorter than 15 days).

The source of P is less important than that of Ca. Although a large amount is derived from vegetal raw materials where it is found in the phytate form, it has been demonstrated that phytinic P has the same efficiency of utilisation as the mineral P (CHEEKE *et al.*, 1985; LEBAS, 1989). In this way, the total amount of P in the diet is the most important thing and must be chosen in order to reduce the waste of P in the environment to a minimum.

The Ca to P ratio does not appear to be particularly important in the nutrition of growing as well as reproducing rabbits, and ratios between 1.5 and 2 to 1 are considered valid (CHEEKE, 1987; MAERTENS, 1992). In any case, Assane *et al.* (1994) observed that the Ca to P ratio did not influence feed intake in non-pregnant does, whereas a low ratio (1:1) stimulated the feed intake of pregnant does. On the contrary, in these females, the highest Ca to P ratio (2:1) improved Ca retention, increased litter size and reduced mortality at birth.

As far as other macrominerals are concerned, there is no new experimental information that allows us to modify the practical feeding recommendations proposed by LEBAS (1989), even if MAERTENS (1995) has recently reduced the recommended levels of Na (from 0.30% to 0.20%) and Cl (from 0.35 to 0.30%) but left those of S (0.25%) and Mg (0.30%) unchanged. As mentioned above for this last mineral, some interactions with Ca have been observed, both in regard to its own absorption and that of other minerals. MESONERO *et al.* (1995) observed that the *in vitro* absorption of L-threonine was more efficient in a isotonic solution containing Mg than Ca.

Mineral absorption can also be influenced by the presence of other dietary components, as reported by WEST *et al.* (1989), whose studies on cholesterolemia in rabbits determined by the use of casein treated with formaldehyde revealed that this protein interfered with the absorption of P and nitrogen.

Oligominerals

The standards suggested by Lebas (1989) have been recently reproposed by MAERTENS (1995), which indicates the virtual absence of significant research on this subject. The only experimental contributions regard the need to reduce the dietary intake of heavy metals (copper) and the interaction between selenium and Vitamin E on the reproductive efficiency of rabbit.

The administration of very high levels of Cu in the sulphate form (75 to 450 mg $CuSO_4$/kg of feed) - values definitely higher than the normal nutritive requirements - has been proposed as a growth promoter due to its positive effect on digestive utilisation of feeds. It is also able to reduce mortality in young rabbits, by protecting them from enterotossemia (CHEEKE, 1987). Even though similar studies were not found on reproducing females, there are some works on growing rabbits that question the utility of this treatment. Using diets with high protein levels (18%), FEKETE *et al.* (1989) observed that the positive effect of Cu supplementation was limited to the first period of growth and negligible on the overall growth period. BASSUNY (1991) found that $CuSO_4$ levels higher than 150 mg/kg can decrease the Fe retention in the liver. Moreover, we must not forget that Cu has a negative environmental impact and a high increase in its soil concentration levels has been caused by its massive utilisation as an auxinic substance in the pig feeding. Based on this scarce information regarding its positive effect and certain of its polluting effect, the supplementation of Cu both in growing and reproducing rabbits must be limited to the normal low levels (10 to 15 mg/kg).

The effect of the association of Se, Vitamin E and Zn on the reproductive performance of male and female adults submitted to thermic stress conditions has been studied (EL-MASRY *et al.*, 1994). A supplementation of 0.7 mg/kg DM of Se and 40 mg/kg DM of Vitamin E determined an increase in testosterone and total spermatozoa concentration in the males, while a further supplementation with 35 mg/kg DM of Zn allowed also an increase in semen volume, live spermatozoa concentration and motility. In the females, the oligomineral and vitamin supplementation lead to a higher conception rate and litter size, as a consequence of the improved chemical and physical semen quality.

A positive effect on foetal growth and litter weight at birth due to dietary supplementation with Se (0.1 mg/kg) was observed by ŠTRUKLEC *et al.* (1994), whereas the supplementation with 0.3 mg/kg determined lower reproductive performance, which could be a sign of approaching levels of toxicity.

The oligomineral and vitamin supplementation was frequently studied to demonstrate the opportunity of adding commercial mixture to the diet in order to improve the mineral and vitamin nutrition of growing and reproducing rabbits. TAWFEEK (1993), supplementing the diet for reproducing does with a similar commercial mixture, obtained higher litter size and weight at birth and heavier weight at weaning as a consequence of higher milk production and lower pup mortality during weaning.

In addition to mineral supplementation by means of salts and oxides, other forms of administration capable of improving the absorption of mineral elements have been tested, such as the protected forms (e.g. oligoelements linked to polysaccharides). In an experiment carried out on females remated 5 to 8 days PP fed the same amount of oligominerals in protected or traditional forms, a higher conception rate (72.7 vs. 65.7%) and a general improvement of reproductive efficiency with lower doe mortality were observed with protected minerals, without any influence on the embryonic mortality and litter size at birth (QUALITECH, 1993).

In any cases, the advantages of these treatments appear to be limited to non-intensive rearing systems, when the commercial diet is completed by farm roughage and by-products or is prepared by industries not specialised in rabbit feeding. The composition of these mixtures is generally unknown and it is not possible to evaluate the assimilability of the different oligominerals. Therefore, the uncontrolled and generalised use of these supplements can increase the heavy metal pollution and should be substituted by a correct supplementation of the complete pelleted feeds.

Probiotics

During recent years, great attention has been given to the use of probiotics, particularly those derived from microbial cultures (yeast and bacteria), administered to encourage the development of a stable and correct microflora in the gut and mostly in the ciecum. Most of the research was carried out to evaluate the efficacy of the probiotics on improving productive performance and health of growing rabbits, whereas the studies on reproducing females were much less numerous. On these animals the experimental results did not always coincide with those observed in young rabbits: in some cases slightly positive responses were observed, with a reduction in the doe mortality and an increase in feed consumption (GUILLOT and MERCIER, 1992; RASHWAN, 1993); in other works no effects on doe performance were found (LAMBERTINI *et al.*, 1990; MAERTENS and DE GROOTE, 1992; MAERTENS *et al.*, 1994). The beneficial effects of adding live yeast to the diet were usually higher under less favourable rearing conditions, with the principal effect of reducing the mortality of young rabbits in the post-weaning period (MAERTENS and DE GROOTE, 1992).

Practical dietary recommendations

Starting from the recommentations proposed by LEBAS (1989) and MAERTENS (1995) and taking into account the recent knowledge above reviewed and the development of breeding systems, dietary nutrient level recommendations are provided in Table 6.

Table 6 : **Practical dietary recommendations for young and reproducing does (diet DM: 88 to 90%).**

Animals Rebreeding system		Young does	Reproducing does Intensive (0 to 10 days PP)	 Semi-intensive (10 to 20 days PP)	 Non-intensive (20 to 30 days PP)
Digestible energy (DE)	MJ/kg	9.5-10	10.8-11.3	10.5-11	10.3-10.7
	kcal/kg	2250-2400	2600-2700	2500-2600	2450-2550
Metabolisable energy	MJ/kg	9.0-9.5	10.5-11.0	10.0-10.5	9.8-10.2
	kcal/kg	2150-2250	2450-2550	2400-2500	2350-2450
Crude protein	%	15.5-16.0	18.0-18.5	17.5-18.0	17.2-17.8
Digestible protein (DP)	%	11.0-11.5	13.0-13.5	12.5-13.0	12.0-12.5
DP to DE ratio		11.5-12	11.8-12.3	11.7-12.2	11.5-12.0
Crude fibre	%	>15.0	>11.5	>12.0	>12.5
NDF	%	>40.0	>33.0	>35.0	>37.0
ADF	%	>18.0	>15.0	>15.5	>16.0
ADL	%	>6.0	>4.5	>4.8	>5.0
Crude fat	%	2.5-3.5	4.0-6.0	3.5-6.0	3.0-5.0
Starch	%	10.0-15.0	15.0-25.0	15.0-25.0	15.0-22.0
Amino acids:					
Lysine	%	>0.75	>0.85	>0.82	>0.80
Methionine+cystine	%	>0.55	>0.62	>0.60	>0.58
Tryptophan	%	>0.13	>0.15	>0.15	>0.15
Threonine	%	>0.58	>0.70	>0.70	>0.68
Leucine	%	>1.05	>1.25	>1.25	>1.20
Isoleucine	%	>0.60	>0.70	>0.70	>0.68
Valine	%	>0.70	>0.85	>0.85	>0.80
Histidine	%	>0.35	>0.43	>0.43	>0.40
Arginine	%	>0.80	>0.90	>0.90	>0.88
Phenylalanine+tyrosine	%	>1.20	>1.40	>1.40	>1.35

Table 6 (cont.) : Practical dietary recommendations for young and reproducing does (diet DM: 88 to 90%).

Animals Rebreeding system		Young does	Reproducing does Intensive (0 to 10 days PP)	 Semi-intensive (10 to 20 days PP)	 Non-intensive (20 to 30 days PP)
Minerals:					
Calcium	%	0.80-0.90	1.30-1.35	1.25-1.30	1.20-1.30
Phosphorus	%	0.50-0.60	0.60-0.65	0.55-0.60	0.55-0.60
Sodium	%	0.20	0.25	0.25	0.25
Chloride	%	0.30	0.35	0.35	0.32
Magnesium	%	0.30	0.30	0.30	0.30
Sulphur	%	0.25	0.25	0.25	0.25
Trace elements:					
Iron	mg/kg	50	100	100	100
Copper	mg/kg	10	10	10	10
Zinc	mg/kg	25	50	50	50
Manganese	mg/kg	5	5	5	5
Cobalt	mg/kg	0.1	0.1	0.1	0.1
Iodine	mg/kg	0.2	0.2	0.2	0.2
Fluorine	mg/kg	0.1	0.1	0.1	0.1
Selenium	mg/kg	0.1-0.2	0.1-0.2	0.1-0.2	0.1-0.2
Vitamins:					
Vit. A	IU/kg	6000	10000	10000	10000
Vit. D	mg/kg	800	1000	1000	1000
Vit. E	mg/kg	30	50	50	50
Vit. K	mg/kg	2	2	2	2
Vit. C	mg/kg	--	100	100	100
Vit. B_1	mg/kg	2	2	2	2
Vit. B_2	mg/kg	6	6	6	6
Panthothenic acid	mg/kg	20	20	20	20
Vit. B_6	mg/kg	2	2	2	2
Vit. B_{12}	mcg/kg	10	10	10	10
Niacin	mg/kg	50	50	50	50
Folic acid	mg/kg	5	5	5	5
Choline chloride	mg/kg	50	100	100	100
Biotin	mg/kg	0.2	0.2	0.2	0.2

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