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FEED AND ENERGY INTAKE IN RABBITS AND CONSEQUENCES ON FARM GLOBAL EFFICIENCY

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ABSTRACT

The paper describes the variations of voluntary feed intake in growing and reproducing rabbits and analyzes the main factors and feeding strategies affecting this variable that plays a key role on feed efficiency, productive response and body energy balance. Feed energy concentration is the main responsible for the ingestion of dry matter and, as a consequence, of the main nutrients. Growth models are given to estimate the changes in daily weight gain and body composition, showing how only rabbits fed to appetite maximize daily energy intake and feed efficiency in the reproducing and fattening sectors.

The main indicator of farm efficiency is global feed conversion ratio (FCR), i.e. the ratio between the quantity of feed consumed in the farm and the total weight of produced rabbits. In growing rabbits, the digestible energy concentration (DE) of the diet explains a great part of the variability of feed intake (R2=0.75) and FCR (R2=0.74); increasing 1 MJ DE/kg diet decreases feed intake by 12 g/d and FCR by 0.29 points; FCR impairs with age from weaning to slaughter with a trend well described (R2=0.99) by a cubic equation. The paper considers other important factors affecting global farm conversion ratio, and also provides estimations of FCR according to doe productivity, mortality rate and market weight.

Key words: Feed & energy intake, rabbits, farm global efficiency

INTRODUCTION

The domestic rabbit is widely reared in most Countries for meat and fur production or as laboratory and pet animal. The environmental and breeding conditions greatly vary from poorly controlled rural rabbitries, gardens and houses or fully controlled commercial farms and experimental laboratory facilities. The high reproductive efficiency and the large feeding adaptability have stated the success of this species in both wild and controlled environments. Despite the potential capability of exploiting a large number of feedstuffs and the limited maintenance requirements of amino acids and vitamins thanks to caecotrophy, rabbit feeding represents a great challenge in intensive rearing systems, for both economic and sanitary reasons. Since several years, rabbit nutritionists are looking for developing feeding strategies capable of i) reducing digestive diseases and the consequent high mortality and morbidity (Lebas *et al.*, 1998; Perez de Rozas *et al.*, 2005; Gidenne and García, 2006), ii) enhancing body condition of reproducing does therefore increasing their reproductive performances and career length (Parigi Bini and Xiccato, 1998; Pascual *et al*., 2003), and iii) increasing feed efficiency so lowering feeding and total production costs (Maertens, 2009).

The main variable that plays a key role on feed utilization and efficiency and productive response is voluntary feed and energy intake. This latter is affected to a different extent by various factors, intrinsic (genetic, physiological and health state) or extrinsic (diet composition, environmental conditions) to the animal (Gidenne and Lebas, 2005). Among dietary factors, feed energy concentration is the main responsible for the ingestion of dry matter and, as a consequence, of the main nutrients, like protein, amino acids and minerals.

Voluntary feed and energy intake

Appetite regulation in rabbits is controlled either by physical factors, that is the volume of ingested feed and its transit in the gut, or by chemiostatic mechanism, according to which the total quantity of energy ingested daily tends to be constant. As reviewed by Parigi Bini and Xiccato (1998) and, more recently, by Xiccato and Trocino (2010), the chemiostatic regulation appears only with a digestible energy (DE) concentration of the diet higher than 9-9.5 MJ/kg. Below this level a physical-type regulation is prevalent and linked to the filling of the gut with the dietary material (Fig. 1).

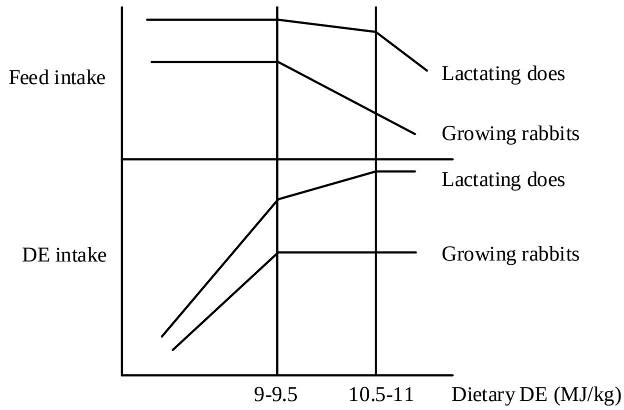

Figure 1. Influence of dietary DE concentration on the voluntary feed and energy intake in lactating does and growing rabbits (from Parigi Bini and Xiccato, 1998).

Growing rabbits in good sanitary conditions consume sufficient feed to meet their energy requirements for maintenance and growth: voluntary energy intake is proportional to metabolic live weight ($LW^{0.75}$), on average 950 kJ DE/d/kg $LW^{0.75}$, i.e. about 2.2 times the energy requirement for maintenance (430 kJ DE/d/kg $LW^{0.75}$). On the other hand, reproducing does have additional needs for pregnancy and/or lactation which often are not covered by an adequate voluntary intake. Lactating females can ingest on average 1100 to 1300 kJ DE/d/kg $LW^{0.75}$, with the lowest value recorded by primiparous females. These rabbits have also a higher energetic limit of chemiostatic regulation compared to growing rabbits and an increase in DE concentration above 9-9.5 MJ/kg until 10.5-11 MJ/kg permits an increase in the daily energy intake. This limit also depends on the dietary energy source, tending to be higher when rabbits are fed fat-added diets rather than high-starch diets.

Feeding of growing rabbits for meat production

Growing rabbits for meat production should be fed to appetite in order to maximize daily weight gain and market weight (Maertens, 1992, 2009). In theoretical condition, the voluntary DE intake (DEI) is utilized for maintenance (45%) and growth (55%), and the overall energy efficiency (retained body energy to DEI ratio) is maximized. When DEI is reduced, body energy retention and overall energy efficiency decreases, because of the reduction of energy available for growth, while energy for maintenance does not change. In practical condition, however, a moderate feed restriction could be used with some advantages on global farm efficiency in comparison with *ad libitum* feeding because: i) it increases digestive efficiency; ii) it modifies the partition of body energy retention as protein instead of fat; iii) it could reduce mortality and morbidity due to digestive troubles.

During the past, feed restriction was proposed with different aims and success. Firstly, feed restriction was a way to improve feed efficiency and standardise the growth curve in animals with different voluntary feed intake (Ouhayoun *et al*., 1986; Ouhayoun, 1989; Cavani *et al*., 1991). Then, feed restriction for a short period after weaning, followed by a final period with free access to feed (re-alimentation), was proposed to reduce the risk of overfeeding and digestive disorders, even if its real effectiveness was never fully demonstrated (Maertens, 1992, Gidenne, 2003). More recently, however, feed rationing practice has been diffused and consolidated as a way to both reduce the mortality due to epizootic rabbit enteropathy and improve global feed conversion (Tudela, 2009).

As mentioned above, the amount of DEI modifies the total quantity of retained energy (RE) in the bodies of growing rabbits and its partition as protein and fat. By using the growth models proposed by Parigi Bini and Xiccato (1986, 1998), daily growth and final body composition in rabbits fed at different feeding levels (80, 85, 90 and 95% of voluntary intake) from 0.7 to 2.5 kg can be estimated (Table 1). A feed restriction up to 90% of the voluntary intake decreases weight gain from 45.3 to 39.9 g/d, delays slaughter time by 5 days, and reduces body fat concentration from 13.8 to 11.7% and energy concentration from 9.81 to 9.08 MJ/kg without appreciable changes in body protein and ash. A more severe restriction (i.e. 80% of voluntary intake) impairs daily weight gain by more than 10 g/d and further modifies body composition.

Table 1. Effect of feeding level from 0.7 to 2.5 kg LW on feed intake, LW gain and final empty body (EB) composition (recalculated from Parigi Bini and Xiccato, 1986 & 1998).

Feeding level (%)	DEI (kJ/d/kg $LW^{0.75}$)	DEI (kJ/d)	Growing period (d)	LW gain (g/d)	EB gain (g/d)	Final EB composition				
						Water (%)	Protein (%)	Fat (%)	Ash (%)	Energy (MJ/kg)
80	800	1136	52.6	34.2	29.8	66.2	21.0	9.4	3.4	8.29
85	850	1207	48.5	37.1	32.3	65.2	20.9	10.6	3.3	8.70
90	900	1278	45.1	39.9	34.7	64.2	20.9	11.7	3.3	9.08
95	950	1349	42.2	42.6	37.1	63.2	20.8	12.7	3.2	9.42
100	1000	1420	39.8	45.3	39.5	62.3	20.8	13.8	3.1	9.81

Feed rationing usually reduces dressing percentage and carcass fatness at slaughter (Ouhayoun, 1989; Cavani *et al*., 1991), but these results are largely dependent on the restriction level and final slaughter weight and should be confirmed in fast-growing hybrid rabbits. Generally speaking, while even slight feeding restriction provokes a sharp decrease in daily growth, a more severe restriction is required to obtain substantial changes in body composition (Xiccato, 1999).

The growth models above have been developed for feed intake levels maintained constant until slaughter and cannot be applied when a restriction period is followed by a final period of re-alimentation. In this latter condition, substantial changes in feed intake behaviour and compensatory growth are observed in the final stage. When feed restriction was modulated during growth by feeding plans (restriction at 80% from 35 to 77 d; restriction at 70% from 35 to 56 d followed by restriction at 90% from 56 d; and restriction at 90% from 35 to 56 d followed by restriction at 70%), the most liberal feeding regime during the second period of growth increased daily growth and feed efficiency, reduced dressing percentage, did not modify the incidence of fat and stimulated muscle to bone ratio (Perrier and Ouhayoun, 1996). However, when strong feed restriction levels (50% or 70% of *ad libitum*) were applied from 35 to 56 d, the compensatory growth during the re-alimentation period was not sufficient to cover the gap with animals fed *ad libitum*, that showed higher final weights and dressing percentages (+12%) and lower fat contents (-25%) (Perrier, 1998).

In a series of experiments with a large number of animals submitted to different rationing levels (from *ad libitum* to 60%) from weaning until 54 d of age followed by re-alimentation until slaughter, feed restriction had significant beneficial effects on health only below 80% of *ad libitum* feeding, while moderate restrictions (80-90%) were not effective or even negative (Boisot *et al*., 2003; Gidenne *et al*., 2003). It has been hypothesised that the lower feed intake slows down the transit rate and increases ammonia-N and caecal pH therefore increasing the risk of diarrhoea (Maertens, 1992, Gidenne, 2003). When feed rationing was more severe (60-70%), mortality and morbidity were significantly reduced, with the minimum values in rabbits fed at only 60% of *ad libitum*, but this feeding level must be considered too low from productive and economic points of view.

In the same experiments, during the restriction period, daily weight gain (DWG) decreased by 0.5 g/d per each percentage of rationing (%RL) in comparison of the *ad libitum* level. Thanks to the compensatory growth, final weight and DWG from weaning until slaughter were less affected (-0.13 g/d per each %RL) but always negatively correlated with the rationing level, according to the following equation (Gidenne *et al*., 2003; Tudela, 2009):

$$\text{DWG (g/d)} = 43.6 - 0.13 \times \%\text{RL} \qquad R^2=0.99.$$

In the opinion of Tudela (2009), the most interesting result, however, was the significant improvement of feed conversion ratio (FCR), as described by the following equation:

$$\text{FCR} = 2.69 - 0.0077\ \%\text{RL} \qquad R^2=0.99.$$

This latter result can be worth of interest, but at the same time irrelevant from an economic point of view if we consider that FCR improved only by 0.08 and 0.15 with feed restriction of 90 and 80% of *ad libitum* intake and the advantage is likely annulled by the longer period of growth needed to reach a similar final weight.

Feeding of young and reproducing does

The great energy excretion through milk in lactating does is not fully compensated by voluntary DE intake, especially in primiparous does, and this causes a consistent deficit in both body tissues and energy (Xiccato, 1996). The nutritional deficit seems to be responsible for the decreased reproductive efficiency of concurrently lactating and pregnant does, which definitively results in a reduction of fertility and does career length and, therefore, in an important loss in global farm efficiency (Parigi Bini and Xiccato, 1998; Castellini, 2007).

The diffusion of high-performance hybrid lines with huge nutritional requirements but unable to ingest a sufficient dietary energy has increased rabbit doe susceptibility to energy deficit. The genetic selection and the crossbreeding programs of the most common European hybrid lines pose the increase in litter size at birth and daily milk production as their main objectives (De Rochambeau, 1990; Maertens, 1992; Khalil and Al-Saef, 2008), while less importance has been given until now to the goal of increasing voluntary feed intake and maintaining the body conditions of the females (Quevedo *et al*., 2005; Theilgaard *et al*., 2007).

While waiting for hybrid lines selected for higher voluntary feed intake, *i*) nutritional strategies to increase feed and energy intake and *ii*) management strategies to reduce body energy output and/or increase body energy recovery have been tested to control the doe energy deficit. Only nutritional strategies will be mentioned here, while management strategies (i.e. parity order, breeding rhythm, litter weaning age) are discussed in other reviews (Pascual *et al*., 2006; Xiccato and Trocino, 2010).

Feeding of young does

From weaning (4-5 weeks of age) to puberty (10-12 weeks) and live weight from 0.8 to 2.5 kg, feeding programs and growth performance of young does are similar to those of rabbits kept for meat production. Later on, from puberty to first mating (16-18 weeks of age) and live weight of 3.2-3.5 kg, the feeding program should permit a correct morphologic and reproductive development and avoid overfattening (Pascual *et al*., 2006; Rommers *et al*., 2006; Xiccato and Trocino, 2008). In this period, voluntary feed intake slightly decreases from 800 to 700 kJ DE/d/kg $LW^{0.75}$ and daily weight gain reduces from 35 to 20 g/d (Xiccato *et al*., 1999).

At 17 weeks of age, breeding rabbits given *ad libitum* access to a diet for fatteners containing 10 MJ DE/kg may reach about 3.4 kg live weight and about 18% body fat (Rommers *et al*., 2006; Xiccato and Trocino, 2008). This condition could be excessive if the further fattening during pregnancy or the quick overfattening (more than 20% fat) in 2-3 weeks in case of failure of pregnancy are considered. Overfattening can provoke subsequent distocia and impaired reproductive performance (Partridge *et al.*, 1986; Parigi Bini *et al.*, 1989; Viudes-de-Castro *et al.*, 1991). On the other hand, an earlier insemination (e.g. 15

weeks) could be too anticipated due to the still incomplete development of endocrine and reproductive systems (Matics *et al*., 2008).

For these reasons, feeding restriction (80-90% of *ad libitum* intake) could be applied to young does for different periods before mating to obtain target weight or age at insemination. In restricted does, to avoid a reduction of sexual receptivity at first insemination, a flushing with a lactation diet given *ad libitum* is usually performed during 4-7 d before first insemination (Rommers *et al.*, 2001, 2002, 2004, 2006; Bonanno *et al.*, 2004).

Feed restriction can continue also in the first part of pregnancy, especially when live weight exceeds target weight, while *ad libitum* feeding with a lactation diet is recommended during the last two weeks of pregnancy to take into account the raising pregnancy requirements and decreasing feed intake nearby kindling (Rommers *et al*., 2004). Restricting feed during the whole pregnancy to the maintenance requirements or even less (75%) reduces body fat and energy reserves, however, to a level which could negatively influences reproductive performance (Fortun *et al*., 1994).

In young does, feeding restriction may also reduce voluntary feed intake in the following pregnancy and lactation and accentuate the risk of a negative energy balance between reproductive cycles (Parigi Bini et al., 1991; Maertens, 1992; Fortun-Lamothe, 1998). On the contrary, the administration of high-fibre low-energy diets (e.g. 19-21% ADF; 8.5-9 MJ DE/kg) to young females before the first mating increases voluntary feed intake during growth, pregnancy and lactation, and partially decreases body fat and energy deficit at the end of first lactation (Nizza et al., 1997; Xiccato et al., 1999; Pascual et al., 2002a).

Feeding of reproducing does

During the first pregnancy, DEI decreases from 600-650 kJ/d/kg LW$^{0.75}$in the first 25 days until 400-450 kJ/d/kg LW$^{0.75}$in the last 5 days, due to the increasing volume of foetuses in the abdomen. The day of kindling, the doe ingests only a little amount of feed or even nothing (Fig. 2).

During lactation, voluntary DE intake substantially raises till 1,500-1,800 kJ/d/kg LW$^{0.75}$ at the lactation peak and 1,100-1,300 kJ/d/kg LW$^{0.75}$on average. After litter weaning, the energy intake quickly decreases in a week at about 35-45% of the lactation level, that is 500-600 kJ DE/d/kg LW$^{0.75}$ (Xiccato *et al.*, 2004 &2005).

A lactation diet, rich in DE (>10.5 MJ/kg) and protein (about 17.5-18%) besides lysine, methionine, calcium, minerals and vitamins (De Blas and Mateos, 1998), is usually given to does few days before kindling, soon after weaning, and until 20-25 d *post partum*. Then does and litters receive a weaning diet, poor in energy and rich in fibre, which safeguards litters from digestive problems, but does not satisfy female requirements (Xiccato

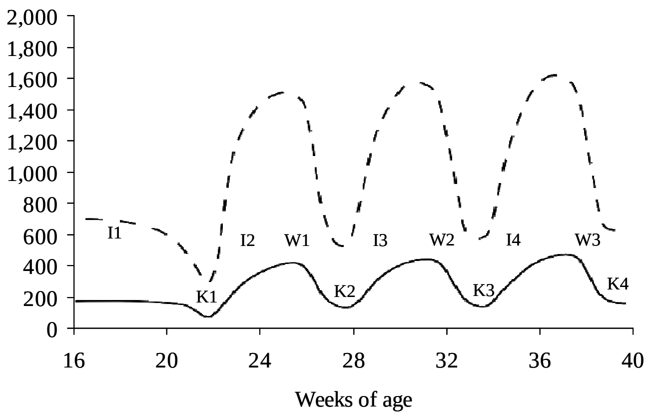

Figure 2. Evolution of voluntary feed intake (g/d) (full line) and DE intake (kJ/d/kg $LW^{0.75}$) (dotted line) from the first insemination to the fourth kindling in does submitted to a 12-days post-partum remating program. I1, I2, I3, I4: 1st, 2nd, 3rd, 4th insemination; K1, K2, K3, K4: 1st, 2nd, 3rd, 4th kindling; W1, W2, W3: 1st, 2nd, 3rd weaning (from Xiccato and Trocino, 2008).

et al., 2006). Therefore, during lactation, the doe's body is subjected to a marked reduction in energy reserves following the mobilisation of the fat deposits (Fig. 3) (Parigi Bini and Xiccato, 1998).

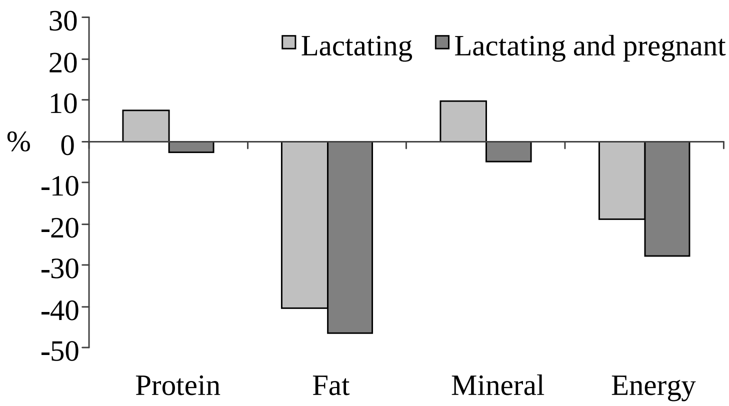

Figure 3. Material and energy balance (% of body content at first kindling) of primiparous does in different physiological states (Parigi Bini and Xiccato, 1993; Xiccato, 1996).

The simultaneous condition of pregnancy is responsible for a further reduction in fat content and body energy levels; it prevents the return to normal body conditions (Parigi Bini and Xiccato 1993; Fortun *et al*., 1993; Fortun-Lamothe and Lebas, 1996; Xiccato *et al*., 2005) 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*., 1992, 1995).

High energy diets have been widely tested in reproducing does to meet their high energy requirements, as reviewed by Pascual *et al.* (2003). During early pregnancy, increasing dietary DE concentration usually reduces DMI and does not change DEI significantly (Pascual *et al.*, 1998, 1999a, 1999b, 2002b). During lactation, feeding high digestible diets increases DEI (Partridge, 1986; Fraga *et al.*, 1989; Maertens and De Groote, 1988; Castellini and Battaglini, 1991; Barreto and De Blas, 1993; Cervera *et al.*, 1993) especially when fat-added diets are used in comparison with high-starch diets (Xiccato *et al.*, 1995; Fortun-Lamothe and Lebas, 1996; Parigi Bini *et al.*, 1996; Pascual *et al.*, 1998; 2002b). The body energy balance of does, however, is always negative and not statistically affected by dietary treatments. In fact, a higher dietary energy supply determines an increase of milk production, impairing its potential beneficial effect on body condition in both primiparous (Xiccato *et al*., 1995; Fortun-Lamothe and Lebas, 1996) (Table 2) and multiparous does (Pascual *et al*., 2000) (Table 3).

Table 2. Effect of dietary energy level on reproductive performance and EB composition at the 28th day of the first lactation in concurrently lactating and pregnant does (Fortun-Lamothe and Lebas, 1996).

	Dietary DE (MJ/kg DM)			Prob.
	9.9 (Control diet)	**12.1 (Fat-added diet)**	**12.2 (Starch diet)**	
Milk production (0-21 d) (kg)	3.8[ab]	4.2[a]	3.6[b]	<0.05
Litter weight at 28th d (kg)	3.9[b]	4.5[a]	3.8[b]	<0.05
EB energy (MJ/kg)	7.85[b]	8.76[a]	9.22[a]	<0.04

Table 3. Effect of dietary energy level on reproductive performance and energy balance of rabbit does at the 28th d of their second lactation (Pascual *et al.*, 2000).

	Dietary DE (MJ/kg DM)		Prob.
	11.0 (Control diet)	**12.4 (Fat-added diet)**	
DE intake (kJ/d/kg LW$^{0.75}$)	1296	1445	<0.01
Milk production (g/d)	191	237	<0.01
Litter weight at weaning (kg)	3.93	4.69	<0.01
EB energy gain (MJ)	-3.33	-3.42	NS

Therefore, the limiting factor on doe productivity is not milk production, but voluntary feed intake: as DEI increases, milk production also tends to increase, thereby impairing, at least partially, the effect of increased DEI on body energy balance.

An increase of 1 kJ in the DEI leads to a proportional increase in milk energy output (+0.434 kJ) and a more limited reduction in the energy deficit (-0.203 kJ) (Xiccato, 1996). The DEI necessary for the doe's body energy equilibrium is 1585 kJ/d/kg $LW^{0.75}$. At this DEI level, the energy milk output is 711 kJ/d/kg $LW^{0.75}$, which corresponds to about 250 g/d of milk in a 4.25-kg rabbit (assuming a milk energy density of 8.5 MJ/kg). Using a diet with 10.5 MJ DE/kg, this female must be able to ingest at least 150 g/d/kg $LW^{0.75}$, i.e. about 450 g/d. Such an average voluntary intake during the entire period of lactation is unusual at least in primiparous and secondiparous does.

Therefore, any intervention performed to stimulate energy intake will rarely provide a substantial reduction of the body energy deficit. In some cases, a contemporary increase in daily energy intake and milk production does not modify the rabbit nutritional state.

In addition to the stimulation of milk production, any increase of DEI is generally associated with increased feed intake. This leads to a faster digestive transit and a consequent reduction in the digestive utilisation of the dietary energy, which makes the objective of solving the energy deficit even more difficult to be achieved (Blas *et al*., 1995; Xiccato, 1996).

Global feed conversion ratio

The main index of farm efficiency is global feed conversion ratio (FCR), i.e. the ratio between the total quantity of feed consumed in the farm and the total weight of produced rabbits. Feed conversion depends on results of both the fattening and the reproductive sectors of the rabbit farm. A global FCR around 3 is expected in efficient commercial intensive farms when rabbits are slaughtered within 2.3 kg live weight (Maertens, 2009), while with higher slaughter live weights (2.5-2.8 kg) FCR around 3.7-3.8 are likely (Xiccato and Trocino, 2007; Xiccato *et al*., 2007).

Dietary DE concentration

As mentioned above, the dietary DE concentration directly influences feed intake and, therefore, FCR. In fact, DE content may explain a great part of the variability of feed intake (R^2=0.75) and feed conversion ratio (R^2=0.74) in growing rabbits fed diets containing 8.0 to 12.0 MJ/kg DE from weaning until 75-79 d of age (Fig. 4) (data from four studies; Xiccato, unpublished data). By the calculated equations (Fig. 4), it appears that increasing the DE concentration of 1 MJ/kg diet feed intake decreases by 12 g/d and FCR by 0.29 points. The use of dietary ADF instead of DE does not increase the precision of the estimations since it is highly correlated to DE concentration (R^2=0.97).

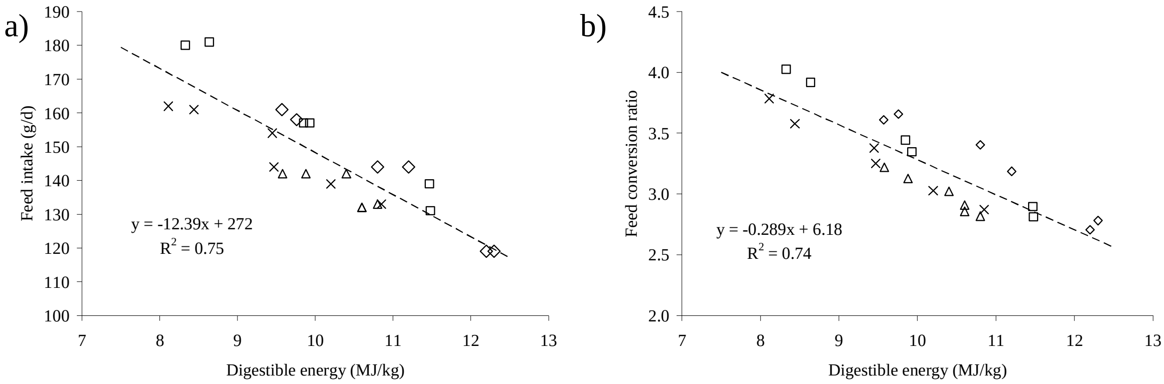

Figure 4. Relationship between DE concentration in diets and feed intake (a) and feed conversion ratio (b) in growing rabbits: data from four studies on rabbits caged individually and reared from weaning (32-34 d) until slaughter (75-79 d) (Xiccato, unpublished data).

Our results agree with those of Maertens (2009) that reported how increasing dietary DE by 1 MJ DE/kg decreases FCR by 0.30-0.40 points. Similar correlation (R^2=0.65) between dietary DE and feed intake were found by Gidenne and Lebas (2005), who showed an even greater correlation between dietary ADF (% as-fed) and feed intake (FI):

$$FI\ (g/d) = -0.079\ ADF(\%)^2 + 5.05\ ADF(\%) + 49.0 \qquad R^2=0.92.$$

Slaughter age and weight

In growing rabbits, FCR impairs with age from weaning to slaughter with a trend which is perfectly described (R^2=0.99) by a cubic equation regardless from the DE value of the diets used (Fig. 5), with an increment of FCR more accentuated in the last period of fattening.

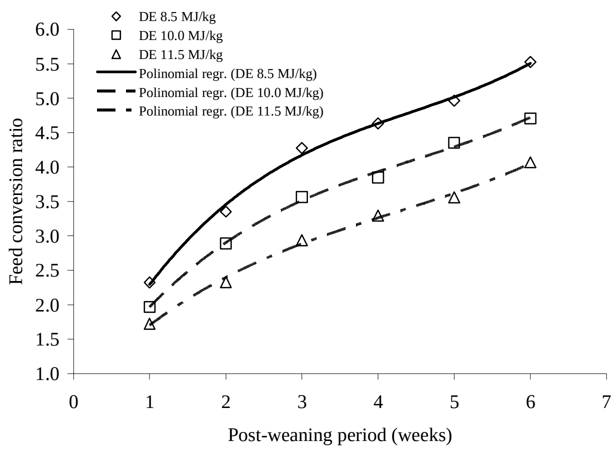

Figure 5. Weekly evolution of FCR during post-weaning and fattening in rabbits fed diets with different DE concentration (Xiccato, unpublished data).

Therefore, when rabbits are slaughtered at higher weights (as the local market may require), FRC of the entire fattening period is negatively affected (Fig. 6).

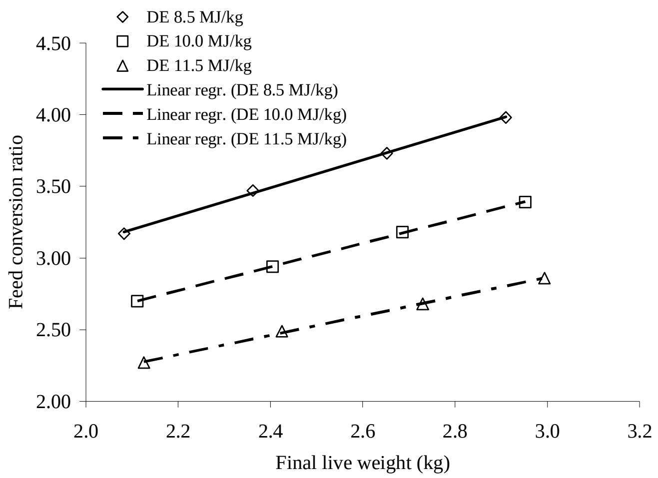

Figure 6. Regression between final LW and FCR during fattening in rabbits fed diets with different DE concentration (Xiccato, unpublished data).

Non-dietary factors

Other important factors must be considered when evaluating global farm FCR, like mortality and doe productivity, which may depend on farm sanitary status and/or technical choices and reproductive performance (e.g. reproductive rhythm, fertility, culling rate, and so on) (Xiccato *et al*., 2007; Rebollar *et al*., 2009). Feeding the current commercial diets, high reproductive performance (62 weaned rabbits/doe/year) are necessary to bear a mortality level in the fattening sector around 10% (Table 4) (Maertens, 2009).

Global farm FCR can be calculated also as a function of both farm production level (no. of produced rabbits/doe/year), that includes the mortality in the reproducing and fattening sectors, and slaughter weight (that considers the different market demand) (Table 5) (Xiccato *et al*., 2007; Maertens, 2009). When reproductive performance are satisfying and the number of produced rabbits/doe/year equal or higher than 55, global FCR may be maintained around or below 3 in animals slaughtered at 2.25 kg. With market weight equal or higher than 2.5 kg, the same production levels permits to maintain FRC at values around or just lower 3.5, that is considered the least acceptable value from an economic point of view.

Table 4. Global farm FCR as affected by the production level in the maternal sector (no. weaned rabbits/doe/year) and mortality (%) in the fattening unit (from Maertens, 2009).

	no. of weaned rabbits/doe/year		
Mortality (%) during fattening	**52**	**57**	**62**
0	3.31	3.03	2.79
5	3.59	3.27	2.93
10	3.79	3.45	3.09
15	4.01	3.66	3.27

Table 5. Global farm FCR as affected by farm production level (no. of produced rabbits/doe/year) and slaughter weight (modified from Xiccato *et al*., 2007; Maertens, 2009)

	no. of produced rabbits/doe/year					
Slaughter weight (kg)	**35**	**40**	**45**	**50**	**55**	**60**
2.00	3.92	3.64	3.39	3.21	3.07	2.97
2.25	4.11	3.79	3.53	3.34	3.19	3.08
2.50	4.38	4.03	3.75	3.55	3.39	3.25
2.75	4.70	4.34	4.05	3.81	3.59	3.45
3.00	5.04	4.69	4.35	4.10	3.85	3.68

Conclusions

Global feed conversion ratio is considered the main index of rabbit farm efficiency that includes feeding, reproduction, management and market factors. Diet composition and feed intake directly influence the value of global FCR: diets and feeding plans must maximize feed efficiency, reduce losses due to digestive troubles in growing rabbits as well as maintain high fertility and prolificacy in reproducing does. Daily energy intake is scarcely modified by the diet composition and dietary energy concentration is the main variable affecting feed intake. Therefore, increasing diet DE improves feed conversion ratio in fattening rabbits, but does not solve or reduce the problem of energy deficit in reproducing females. Only *ad libitum* feeding permits to maximize daily energy intake and feed efficiency in the reproducing and fattening sectors, whereas a moderate feed restriction could be supplied to nulliparous rabbits before first insemination to avoid overfattening and to young rabbits after weaning if the beneficial effect on digestive health will be confirmed by further studies. Global farm conversion ratio could be substantially reduced by increasing dietary energy concentration and reproductive efficiency, controlling mortality and lowering rabbit slaughter weight.

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