EFFECTS OF DIETARY ENERGY LEVEL AND ORIGIN (STARCH *vs* OIL) ON PERFORMANCE OF RABBITS DOES AND THEIR LITTERS : AVERAGE SITUATION AFTER 4 WEANINGS

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Abstract - The aim of this experiment was to study the effects of dietary energy level and origin on reproductive performance of rabbit does during four successive cycles. Does were given a moderate-energy diet (~2400 kacl/kg DM; Group M, n=22) or a high-energy diet (~2900 kcal/kg DM). In this case, additional energy come from starch (Group S, n=21) or starch and fat (Group F, n=22). Fertility rate (50 %) and remating interval (49 d) were similar in the three groups. During overall experiment, feed intake was 20.7 % higher in the M group than in the two other groups ($P < 0.0001$), but DE intake was similar in the three groups (899 kcal/d). Live weight of the does was similar in the three groups the whole experiment long. Percentage of new born dead (-50 %; $P < 0.0001$) and mortality of young rabbits during lactation (-48 %; $P < 0.05$) were lower in the M group than in the other groups. Estimated milk production was 11 % lower in the S group than in the 2 others ($P < 0.01$). These results did not demonstrate any positive effects of high-energy diet on middle term reproductive performance of rabbit does. On the contrary, they suggest a negative effect of high starch level in the diet on young rabbit mortality and growth.

INTRODUCTION

In a previous study, we have studied the effects of dietary energy level and source on reproductive performance and body composition of primiparous pregnant-and-lactating rabbit does (FORTUN & LEBAS, 1994; FORTUN-LAMOTHE & LEBAS, 1995). One of the conclusions point out the reduced depletion of body stores at the end of the first lactation, with the increase of the dietary energy concentration. This "better" body condition of the does at the end of the first reproduction cycle was also dependant of the origin of the energy source employed: starch or lipids. In addition, one of the questions was the consequence of the body status of the doe at the end of the first cycle, on the following reproductive cycles.
The aim of the present work was the study the effects of the same 3 diets employed until the 4th weaning, with does mated shortly after each kindling.

MATERIALS AND METHODS

Diets

The three diets used were previously described by FORTUN and LEBAS (1994). The digestible energy (DE) content of the M diet was moderate (2364 kcal/kg DM), while DE content of the two other diets was high (~2900 kcal/kg DM). In the S diet, additional energy comes from starch, and in the F diet from fat (sunflower oil) and starch. Digestibility of the diets was previously measured *in vivo* with pregnant-and-lactating does (FORTUN and LEBAS, 1994). Composition and digestibility of the diets are reminded in table 1.

Animals

One hundred and one primiparous crossbred does (from a mating between A2066 bucks and A1077 does) were assigned at parturition to one of the three experimental groups, corresponding to the distribution of one of the three experimental diets. Females were caged individually with a controlled light/dark cycle (16 h / 8 h), and had free access to the experimental diet.

Table 1 : Ingredients, composition and digestibility (kcal/kg DM) of the diets

Diet	S	F	M
Components (%)			
Wheat	19.0	19.0	19.9
Alfalfa 17LP	20.8	20.8	20.8
Soybean meal	16.8	16.8	15.9
Sunflower meal	15.0	15.0	15.0
Beat pulp	11.4	11.4	11.4
Maize starch	14.0	7.4	-
Wheat straw	-	-	14.0
Wood fiber	-	3.6	-
Sunflower oil	-	3.0	-
Salts and vitamins	3.0	3.0	3.0
Chemical composition and digestible nutrients (% DM)			
Dry matter	88.2	88.8	89.0
Organic matter	91.3	91.3	90.7
Ash	8.7	8.7	9.3
Ether extract	2.0	5.2	2.0
Crude fiber	14.2	17.7	19.3
Crude proteins	20.7	20.3	20.7
Digestible proteins	14.8	14.6	13.6
Gross energy	4260	4418	4363
Digestible energy	2923	2899	2364

Does were presented to the male 3-4 days after parturition (intensive reproductive rhythm on fixed day in the week), and if necessary each week thereafter until a fertile mating. Does were discarded for two reasons : pathology or fertility (3 consecutive sterile matings or 6 consecutive male refusals).

At parturition, litter size were equalized when possible, at 9 young rabbits after crossfostering. Young rabbits were weaned when 28 days-old. Does and their young were weighed weekly, and feed intake was determined at that time. Milk production between days 0 and 21 was estimated from litter growth : the conversion index of rabbit milk is about 1.82 (LEBAS, 1969).

Body composition

All does were slaughtered at the 4th weaning in order to study body composition. At slaughter, does were dissected and carcass (muscles, lungs, heart and bones), skin, full digestive tract (with gut fill), dissectable adipose tissues (perirenal and interscapular), liver and kidneys were weighed. Empty body was defined as carcass + skin + kidneys + liver + adipose tissues.

Statistical Analyses

Data were analysed by analysis of variance, using the general linear procedure (GLM; SAS, 1988). For body composition the main effect was treatment. The live weight, parameters of fertility, and litter's traits were analysed according to a split-plot design including the effect of treatment, the effect of parity, the treatment x parity interaction, and the effect of rabbit doe within treatment (error to test the treatment effect). For feed intake, the physiological state of the doe (pregnant, lactating or simultaneously pregnant and lactating) was also included in the model. When treatments differed, comparisons of the means were tested using the Student-Newmann-Keuls' procedure. Mortality rate of young rabbits (at birth and during lactation) was analyzed with the chi-square's method.

RESULTS

Eight percent of the does died before the 4th weaning and 28 % of the initial does were discarded during the experiment (table 2). Therefore, 65 females were present and were slaughtered at the end of the experiment (21, 22, and 22 in the S, F and M groups respectively). There was no significant difference between the three groups concerning does elimination. The different following performance analysis concern only these 65 does.

Table 2 : Evolution of rabbit does population of each group during the experiment (first parturition to fourth weaning).

Group	S	F	M
Initial number	33	35	33
Eliminated for			
* problem of fertility	7	4	7
* pathology	3	6	1
Dead	2	3	3
Alive at the end	21	22	22

Theoretical parturition interval was 35 days, but actual parturition interval was 49 days. This could be explained by moderate acceptance rate of the male (~ 73 %) and conception rate (~ 50 %). There was no difference between the three groups for these parameters, neither for the number of service per conception (2.3 ± 0.1; table 3).

During overall the experiment (from first kindling to 4th weaning = 175 ± 4 days), average feed intake was significantly higher in the M group (+20.7 %; $P < 0.001$; figure 1). During gestation, feed intake was similar in the S and F groups (226 g ± 26). On the opposite, during the three first weeks of lactation feed intake was higher in the F group than in the S group (+12.5 %; $P < 0.01$). During the last week of lactation feed intake was significantly lower in the F group than in the S group (-5.2 %; $P < 0.05$). Physiological status of the doe had a significant effect on feed intake. During pregnancy, this latter was higher for simultaneously pregnant and lactating does than for pregnant does (331 ± 9 vs 160 ± 3; $P < 0.0001$). During lactation, feed intake was higher for simultaneously pregnant and lactating does than for lactating does (405 ± 7 vs 351 ± 5; $P < 0.0001$). Moreover, feed intake increased significantly with parity ($P < 0.0001$).

Table 3 : Effects of origin and energy content of the diet on the parameters of fertility.

Group	S	F	M
No does	21	22	22
No litters	84	88	88
Parturition interval (d)	49.0 ± 2	49.2 ± 2	48.8 ± 2
Acceptance rate (%)	67.4 ± 4	77.9 ± 3	72.4 ± 3
Conception rate (%)	48.8 ± 4	50.6 ± 4	50.6 ± 4
Services per conception	2.4 ± 0.2	2.3 ± 0.1	2.3 ± 0.1

There was no significant difference between groups for DE intake during overall the experiment (898.7 ± 20 kcal/day) and during pregnancy (figure 2). Nevertheless, during the three first weeks of lactation, DE intake was significantly higher in the F group than in the two others (+10.7 %; $P < 0.01$).

We could not demonstrate any significant effect of the diets on the evolution of the live weight of the does during the reproductive cycles (figure 3). Live weight was significantly lower at the time of a fertile mating (3946 ± 41 g) than at the time of a sterile mating (4012 ± 39 g; $P < 0.05$).

At slaughter, the weights of carcass, skin, and kidneys were similar between the three groups (table 4). Empty body weight was 5.7 % higher in the S group than in the group F ($P < 0.10$). The weight of adipose tissues was 61.5 % higher in the groups of does receiving high-energy diet than in the M group ($P < 0.10$). Full digestive tract was lighter in the F group than in the two others ($P < 0.05$), and liver was heavier in the S group than in the two other groups ($P < 0.0001$).

Figure 1 : Evolution of does feed intake during a reproduction cycle

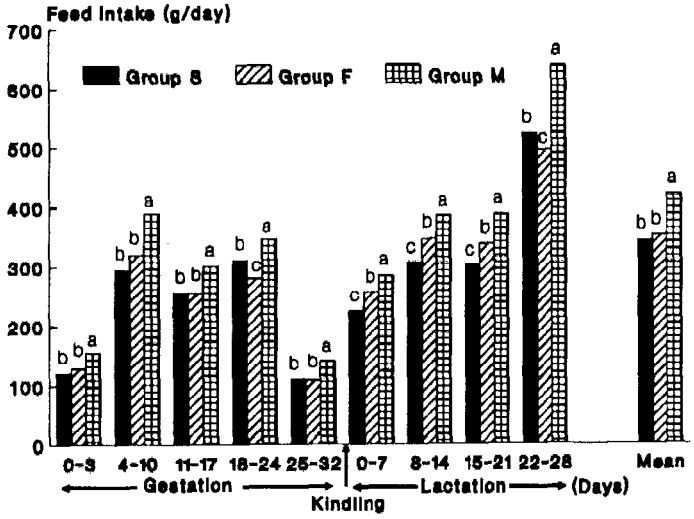


Figure 2 : Evolution of does digestible energy intake during a reproduction cycle.

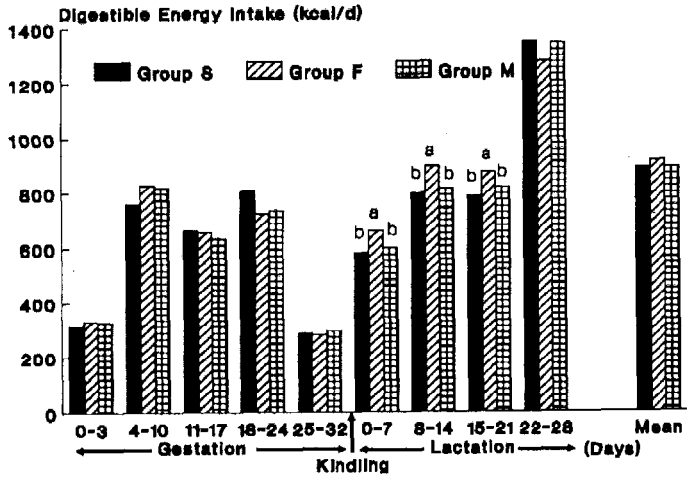
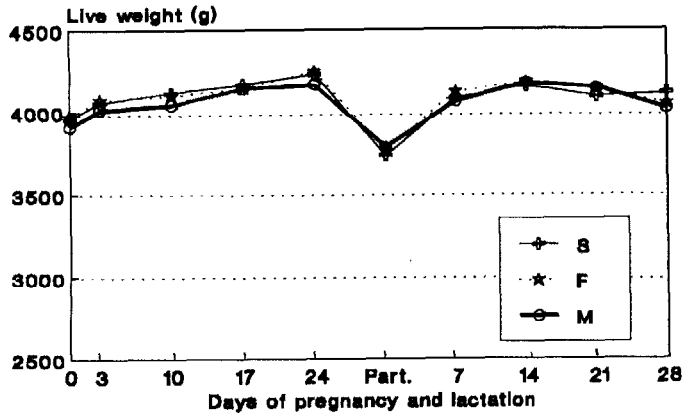


Figure 3 : Evolution of the does live weight during a reproduction cycle.



Number of young born alive per litter was similar in the three groups. On the opposite the percentage of dead-born was significantly higher in the F and S groups than in the M one ($P < 0.001$). Moreover, mortality rate of young rabbits during lactating was lower in the M group than in the two others ($P < 0.05$; table 5). The mean weight of young rabbits was lower in the group S than in the two others groups at birth (-8.6 %; $P < 0.05$) and at day 21 of lactation (9.9 %; $P < 0.001$). Estimated milk production was 11 % lower in the S group than in the two other groups ($P < 0.01$).

DISCUSSION

These results did not demonstrate any positive effects of high-energy diet on middle term reproductive performance of rabbit does. On the contrary, they suggest a negative effect of high starch level in the diet on young rabbit mortality and growth, as it was observed in our conditions with primiparous does (FORTUN and LEBAS, 1994). This is in opposition with the results of PARIGI-BINI and XICCATO (1993) and VIUDES DE CASTRO *et al* (1993) which observed a reduction of the litter size with high energy diets (fat addition).

The higher birth to weaning mortality associated with high DE concentration may be related with milk quality, since milk of does of the S and F group has a lower content in protein than milk of the M group does (LEBAS *et al.*, 1996). Nevertheless, it must be emphasized that the main effect of diet on milk composition is on the fat composition directly related with fat content of the diet.

This first analysis of the results take in consideration only the average performance per reproduction cycle of does alive at the end. A further analysis should be done on the basis of productivity per time unit including the culled does production as it was done by BARETTO and DE BLAS (1993).

Table 4 : Effects of origin and energy content of the diet on traits of body composition (g) at slaughter

Group	S	F	M	Contrast S+F vs M	Contrast S vs F
No does	21	22	22		
Live weight	4302.6 ± 79	4169.6 ± 72	4238.6 ± 73	ns	ns
Empty body	3202.1 ± 77	3021.0 ± 77	3070.3 ± 69	ns	0.1
Carcass	2226.9 ± 63	2118.6 ± 55	2157.6 ± 37	ns	ns
Skin	738.1 ± 20	691.5 ± 22	727.3 ± 28	ns	ns
Digestive tract	[a] 819.2 ± 23	[b] 749.0 ± 19	[a] 831.4 ± 26	0.1	0.05
Liver	[a] 166.6 ± 4	[b] 137.6 ± 4	[b] 133.3 ± 5	0.01	0.001
Adipose tissues	49.2 ± 6	48.4 ± 9	30.2 ± 6	0.1	ns
Kidneys	21.3 ± 1	24.9 ± 3	21.9 ± 1	ns	ns

[a,b,c] Groups with different letters differ at $P < 0.05$

Table 5 : Effects of origin and energy content of the diet on litter size and litter growth during lactation

Group	S	F	M	Contrast S+ F vs M	Contrast S vs F
No does	21	22	22		
No litters	84	88	88		
Litter Size					
Total	10.8 ± 0.3	10.7 ± 0.3	10.3 ± 0.4	ns	ns
Born alive	9.5 ± 0.5	9.8 ± 0.3	9.8 ± 0.4	ns	ns
Dead born (%)	[a] 12.0 ± 3.3	[b] 8.4 ± 2.2	[c] 4.9 ± 2.1	0.001	0.05
Equalization	9.0 ± 0.0	9.0 ± 0.0	8.9 ± 0.0	0.1	ns
Weaning	8.4 ± 0.1	8.4 ± 0.1	8.6 ± 0.1	ns	ns
Mortality 0 28d (%)	[a] 6.6 ± 1.0	[a] 6.6 ± 1.3	[b] 3.4 ± 0.8	0.01	ns
Young rabbits individual weight					
Birth	[b] 53.8 ± 1.8	[a] 58.3 ± 1.0	[a] 59.4 ± 1.3	0.05	0.05
day 21	[b] 294.1 ± 4.9	[a] 332.6 ± 5.0	[a] 319.9 ± 5.2	ns	0.001
day 28	536.2 ± 8.2	571.4 ± 9.2	543.0 ± 9.3	ns	0.05
Milk production (g)	[b] 3662.8 ± 80	[a] 4181.2 ± 90	[a] 4050.0 ± 73	ns	0.001

[a,b,c] Groups with different letters differ at $P < 0.05$

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Effets du niveau et de la source d'énergie alimentaire (amidon *vs* huile) sur les performances des lapines et de leurs portées : moyennes après quatre sevrages - Cent une lapines primipares croisées d'une souche Californien x Néo-Zélandais ont été suivies durant quatre cycles successifs de reproduction. Les femelles ont reçu un aliment à teneur moyenne en énergie (2400 Kcal/kg MS ; Groupe M, n = 22) ou un aliment à forte teneur en énergie (2900 Kcal/kg MS). L'énergie supplémentaire provenait d'amidon (Groupe S, n = 21) ou d'amidon et d'huile de tournesol (Groupe F, n = 22). Le taux de fertilité (50 %) et l'intervalle entre saillies (49 jours) ont été similaires dans les trois groupes. Sur la période globale d'expérimentation, la consommation des animaux a été plus élevée (+ 20.7 %) dans le Groupe M que dans les deux autres groupes ($P < 0.0001$), mais la consommation d'énergie nette a été semblable dans les trois groupes (899 Kcal/jour). Le poids vif des femelles n'a pas été influencé par le type d'alimentation (4000 g en moyenne).
Le pourcentage de morts-nés (- 50 % ; $P < 0.0001$) et la mortalité des lapereaux durant la lactation (- 48 % ; $P < 0.05$) ont été plus faibles dans le Groupe M que dans les autres groupes. La production de lait estimée des lapines a été inférieure de 11 % dans le Groupe S à la production de lait des lapines des deux autres groupes ($P < 0.01$). Ces résultats n'ont permis de mettre en évidence aucun effet positif de l'aliment riche en énergie sur les performances de reproduction des lapines. Au contraire, ils suggèrent un effet négatif de la forte teneur en amidon dans l'aliment des mères sur la mortalité et la croissance des lapereaux.