EFFECTS OF DIETARY ENERGY LEVEL AND ORIGIN (STARCH *VS* OIL) ON GROSS AND FATTY ACID COMPOSITION OF RABBIT MILK

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Abstract - The aim of this experiment was to study the effects of dietary energy level and origin on milk composition of rabbit does. Lactating rabbit does were fed a moderate-energy diet (2364 kcal/kg DM ; Group M), or a high-energy diet (~ 2900 kcal/kg DM). Additional energy (+25%) comes from starch (Group S) or starch and fat (3% of sunflower oil; Group F). The three diets had similar protein content. Milk samples were obtained on day 16 or 17 of lactation (n=17 for each treatment). The diet given to the does had no significant effect on the dry matter (DM) content of the milk (27.3% on average). Digestible energy increasing induced a significantly (P<0.01) lower protein content of milk (44.8% and 44.7% of DM for S and F groups) when compared to results obtained with diet M (48.6% DM). The lipid content tended to be higher in the milk of the does given the F diet (P=0.070). The medium chain fatty acids proportion in milk (C8 to C15) was significantly lower (54.7%) in the milk of the F group does than in the milk of the two other groups of does (64.2% and 64.7% for M and S). Oil addition in F diet induced an increase of C18:0, C18:1 and C18:2 (for the latter19.8% of fatty acids *vs* 9.4% for M) and a reduction for the other fatty acids. Digestible energy increasing with starch induced a decrease of polyunsaturated fatty acids proportion when compared to M control (from 9.4% to 7.8% for C18:2 and from 2.53% to 1.78% for C18:3) but insignificant variations of the other fatty acids of milk.

INTRODUCTION

In previous experiments we studied the effect of energy level and source on the reproductive performance of primiparous (FORTUN-LAMOTHE and LEBAS, 1995) and multiparous (LEBAS and FORTUN-LAMOTHE, 1996) rabbit does. The energy source (starch *vs* fat) and level (high-energy diet *vs* moderate-energy diet) influenced the growth of suckling rabbits : the diet containing fat led to the highest rabbit weight whereas the diet containing starch led to the lowest rabbit weight. This influence of the diet on young rabbit growth could have been mediated by modifications in milk production and/or milk composition. Therefore, the aim of this experiment was to study with the same diets, the effects of energy level and source on the milk composition of rabbit does.

MATERIAL AND METHODS

Experimental diets

The three diets used in this experiment have been previously described (LEBAS and FORTUN-LAMOTHE, 1996). The control diet had a moderate-digestible energy content (diet M). The two other diets have a higher (+25%) digestible energy content. They were obtained through an addition of starch (diet S) or starch and sunflower oil (diet F). The ingredients used and the chemical composition of the diets are reminded on table 1.

Animals and milk sampling

The does (INRA 1067 line) were assigned at their first parturition to one of the three experimental groups, corresponding to the distribution of one of the three experimental diets. The milk samples (n=17 in each groups) were obtained on day 16 or 17 of the 3rd or the 4th lactation. The milk (10 to 15 ml) was obtained with a manual apparatus similar to that described by SCHLEY (1975), after an injection of 1 to 3 IU of ocytocine (SCHLEY, 1975).

Samples analysis

The gross composition of the milk was determined after freeze drying. Dry matter (103°C , 24 h), crude proteins (N x 6.38), lipids (methanol-chloroform extraction) and ash (550°C , 5 h) were determined for each milk samples. The lactose content was estimated by difference (organic matter minus crude protein and lipids).

The fatty acid proportions were estimated by gas chromatography after methanol-chloroform extraction (SUKHIJA and PALMQUIST (1988). Pure C19 fatty acid (Sigma N5252) and methyl-C19 fatty acid (Sigma N5377) were used as internal controls. A reference lipids pack, including C4 to C24 fatty acids (Sigma 189-19) was used as standard.

Statistical analysis

Statistical analysis of the data was made with the SAS-STAT package (SAS, 1988) through a one way variance analysis. When pertinent, means were compared with Newman & Keuls test.

RESULTS

Milk Gross Composition

The diets had no significant effect on the milk dry matter content (Table 2). On the contrary, the protein content was 7.8% lower in the milk of the S and F groups does than in the milk of the M group does ($P < 0.005$). Moreover, the lipids content tended to be higher in the milk of the does given the F diet ($P=0.070$).

Table 1 : Ingredients and chemical composition of the diets

DIETS	S	F	M
Ingredients (% as fed)			
- 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
- Beet pulp	11.4	11.4	11.4
- Maize starch	14.0	7.4	-
- Wheat straw	-	-	14.0
- Wood cellulose	-	3.6	-
- Sunflower oil	-	3.0	-
- Salts & Minerals	3.0	3.0	3.0
Chemical composition (% DM) and Digestible energy (kcal/kg DM)			
- Dry matter	88.2	88.8	89.0
- Ash	8.7	8.7	9.3
- Ether extract	2.0	5.2	2.0
- Crude fibre	14.2	17.7	19.3
- Crude protein	20.7	20.3	20.7
- Gross energy	4260	4418	4363
- Digestible energy	2923	2899	2364
Lipids fatty acid proportions (%)			
- C16:0	17.4	11.0	19.7
- C18:0	3.4	3.8	4.0
- C18:1	26.4	30.9	27.2
- C18:2	43.9	51.5	41.8
- C18:3	8.8	2.7	7.2
- indeterminate	0.1	0.1	0.1

Table 2 : Gross Composition of milk in relation with does diets - means and residual coefficients of variation

DIETS	S	F	M	residual coef. variat	Signification (P)
- Dry matter (%)	28.11	26.09	27.77	11.7%	ns
as % of Dry Matter					
- Proteins	44.84^{a}	44.74^{a}	48.60^{b}	7.8%	0.005
- Lipids	35.54	37.62	34.22	11.6%	0.070
- Ash	8.55	8.01	8.14	15.9%	ns
- Lactose (1)	10.8	9.3	8.7	30.0%	ns

(1) estimation

Fatty acid composition

The diet's digestible energy increase by starch addition induced only small variations of milk lipids fatty acids composition (table 3). On the contrary digestible energy improvement with oil addition (diet F) induced a significant modification of most of the 16 fatty acids detected in the does milk.

Relatively to the control diet M, diet's digestible energy increase with starch (diet S) induced a significant increase in myristic acid (C14, +18%) and a decrease for polyunsaturated linoleic and linolenic acids (C18:2, -17% ; C18:3 -24%). No significant modification was observed for any of the other fatty acids but for C14:0 which represents only 1.4% of the total fatty acids on average (table 3).

On the contrary relatively to the same control diet M, diet's digestible energy increase with oil and starch (diet F) induced a significant modification for 10 out of the 16 fatty acids present in the milk. A significant increase was observed for C18:0 (+16%), C18:1 (+28%) and especially for C18:2 (+109%). For all the other fatty acids, a reduction in the proportion was observed, significant for 7 out of 13. Especially, the main fatty acid C:8 was reduced from 33% of the total fatty acids with diet M to 27% with diet F. In addition we can underline that the content of odd fatty acids (C15, C17:0 and C17:1), which are mainly synthesised by bacteria in the caecum, was 25.3% lower in the milk of the F group does than in the milk of the M group does ($P < 0.0001$). A similar reduction was not observed with diet S.

According to these results we can conclude that in our case the digestible energy increase has no specific effect on the fatty acid composition of milk, but on the contrary, the origin of digestible energy is able to influence widely this composition.

Table 3 : Fatty acid composition of the milk in relation with does diet - means and residual coefficients of variation.

DIETS	S	F	M	residual coef. variat	Signification (P)
Individual fatty acid (%)					
- C6	$^{a}0.46$	$^{b}0.30$	$^{a}0.52$	24.6%	<0.001
- C8	$^{a}32.53$	$^{b}26.61$	$^{a}32.94$	11.7%	<0.001
- C10	$^{a}26.40$	$^{b}23.34$	$^{a}26.03$	10.4%	0.024
- C12	4.11	3.66	3.79	20.4%	ns
- C14:0	$^{a}1.64$	$^{c}1.15$	$^{b}1.39$	18.0%	<0.001
- C14:1	0.05	0.00	0.04	>100%	0.073
- C15	$^{a}0.30$	$^{b}0.25$	$^{a}0.32$	12.4%	<0.001
- C16:0	$^{a}11.40$	$^{b}8.94$	$^{ab}10.38$	22.7%	0.013
- C16:1	$^{a}1.41$	$^{b}0.69$	$^{ab}1.12$	63.3%	0.013
- C17:0	$^{a}0.36$	$^{b}0.28$	$^{a}0.38$	12.7%	<0.001
- C17:1	0.02	0.00	0.01	>100%	ns
- C18:0	$^{b}2.47$	$^{a}2.83$	$^{b}2.44$	17.4%	0.027
- C18:1	$^{b}7.62$	$^{a}9.08$	$^{b}7.12$	20.0%	0.022
- C18:2	$^{c}7.83$	$^{a}19.76$	$^{b}9.44$	6.6%	<0.001
- C18:3	$^{b}1.93$	$^{c}1.78$	a2.53	6.8%	<0.001
- C22:1	1.03	0.99	1.08	27.7%	ns
- non identif.	$^{a}0.52$	$^{b}0.25$	$^{ab}0.37$	80.4%	0.041
Fatty acids gathered together					
- Unsat./Saturated	$^{b}0.254$	$^{a}0.482$	$^{b}0.275$	15.0%	<0.001
- Polyunsaturated	$^{c}9.76$	$^{a}21.53$	$^{b}11.97$	6.4%	<0.001
- Odd fatty acids	$^{a}0.68$	$^{b}0.53$	$^{a}0.71$	15.5%	<0.001

DISCUSSION

Previous experiments reported no influence of either dietary energy level or addition of fat in the diet on the gross chemical composition of the milk (KAMAR *et al.*, 1985 ; FRAGA *et al.*, 1989 ; De BLAS *et al.*, 1995 ; XICCATO *et al.*, 1995). On the opposite, in the present experiment, an increased digestible energy content of the diet led to a decreased protein content of the milk. That could be partly explained by a decrease of the digestible protein to DE ratio (DP/DE ratio) of the diets: 57 g/1000 kcal in the M diet to 50 g/1000 kcal in the S and F diets. Nevertheless it must be emphasized that with a similar variation in digestible energy content and in DP/DE ratio, FRAGA *et al* . (1989) have not observed any significant variation of the milk protein content.

The dietary energy level had no specific effects on the fatty acid profile of the milk. On the opposite, the dietary energy source influences greatly the milk fatty acid proportions. The proportion of long-chain fatty acids was higher in the milk of the does given the diet containing sunflower oil. This is in accordance with the results of FRAGA *et al.* (1989) showing a higher proportion of long-chain fatty acids in the milk of the does receiving a diet supplemented with 3.5% of fat (pork lard). Nevertheless, the modification of the milk fatty acid profile seems to be dependant of the dietary source of lipids.

The odd fatty acid proportion was reduced in the milk of the does given a diet containing fat. Odd fatty acids have a bacterial origin. Therefore, the caecal fermentation activity could have been reduced in the does eating the F diet.

The mortality rate of young rabbits during lactation was higher in the S and F groups than in the M group. (LEBAS and FORTUN-LAMOTHE, 1996). That could be related to the lower protein content of the milk in these two groups, but we have no physiological suggestion to explain such a relation.
Moreover, the weight of suckling rabbit on day 21 of lactation was higher in the group F and lower in the group S than in the group M. These differences are necessary in relation with milk synthesis and milk nutrients production. The young weight differences may be partly explained by modifications of the milk fatty acid profile of the mothers described here, even if the modifications observed with diet S were not very important. Nevertheless, a quantitative modification of milk production is most probably the main explanation of growth differences.

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Effets de la teneur et de l'origine (amidon *vs* huile) de l'énergie de l'aliment sur la composition et les proportions d'acides gras du lait chez la lapine - Des lapines allaitantes ont reçu l'un des trois aliments isoproteiques suivants: aliment M à teneur modérée en énergie (2364 kcal/kg MS), aliments S et F à teneur élevée en énergie (+25%, ~2900kcal/kg MS). L'aliment S est enrichi en amidon et l'aliment F est enrichi en amidon et en huile de tournesol (3%). Des échantillons de lait (n=17 dans chaque lot) ont été obtenus au 16ème ou au 17ème jour de lactation. La teneur ou l'origine de l'énergie digestible n'ont eu aucune influence significative sur la teneur en matière sèche du lait (27,3%). L'accroissement de la teneur en énergie digestible des aliments a entraîné une réduction significative de la teneur en protéines du lait : 44,8% et 44,7% de la MS avec les aliments S et F contre 48,6% avec l'aliment M. La teneur en lipides du lait tend à s'accroître après addition d'huile à l'alimentation des lapines (P=0,070). Dans le lait des lapines des 3 lots, 14 à 16 acides gras ont été identifiés, du C6 au C22:1. Le profil en acides gras du lait est peu modifié lorsque l'augmentation de l'énergie est assurée par de l'amidon. Il est surtout observé une réduction des proportions des acides gras polyinsaturés C18:2 (-17%) et C18:3 (-24%). L'ensemble des acides gras à chaîne moyenne (de C8 à C15) représente 64,2% des acides gras totaux avec l'aliment M et 64,7% avec l'aliment S, mais seulement 54,7% avec l'aliment F. L'augmentation de la concentration énergétique de l'aliment par apport d'huile (lot F) entraîne une augmentation significative de 3 des acides gras à 18 carbones C18:0 (+16%), C18:1 (28%) et C18:2 (+109%). Ainsi, dans le lait des lapines du lot F, l'acide linoléique (C18:2) représente 19,8% des acides gras, alors que cette proportion n'est que de 9,4% et 7,8% pour les lapines des lots M et S respectivement. Par contre, l'usage de ce même aliment F entraîne une réduction de la proportion de tous les autres acides gras, réduction significative pour 9 des 13 acides concernés.