KRMIVA

DIETARY FAT IN SOW NUTRITION

MAST U HRANIDBI KRMAčA

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SUMMARY

A total of 63 primiparous hybrid sows were used in two experiments to study the effect of different fat levels in the lactation diet on the energy balance (EB), heat production and nitrogen banalce (NB) of animals. The experiments were made to measure the efficiency of milk production of sows from metabolizable energy of feed. In experiment 1 the major difference in energy sources in the lactation diets were tapioca starch or animal fat. Fifteen sows received the low-fat diet (starch and fat content: 396; 43 g/kg DM) and 16 sows were fed a moderate fat-level diet (starch and fat content: 286; 75 g/kg DM) during 4 weeks of lactation. In experiment 2 cornstarch (200 g/kg) was substituted by animal fat. Sixteen sows were fed during 4 weeks of lactation a low-fat diet (starch and fat content: 418; 37 g/kg DM) and 16 were fed a high-fat diet (starch and fat content: 266; 125 g/kg DM).

In both experiments EB and NB of sows were measured between days 18 and 25 of lactation in respiration chambers. It was established that sows fed a high level of dietary fat produced more milk energy and less heat ($P < 0.05$). The efficiency of milk production from ME was improved ($P < 0.05$) with high dietary fat compared to low-fat diet. Animals fed the high fat level had a more negative EB ($P < 0.05$) when ME intake was controlled. The NB and milk yield were not affected by the dietary fat levels.

Key Words: Sow, Fat, Energy balance, Heat production, Nitrogen balance.

INTRODUCTION

Weight losses of sows during lactation can vary considerably. In cases where sows do not consume sufficient energy for milk production and/or when they have a large litter they are in negative energy balance (Drochner, 1989). This negative energy balance of sows during lactation may affect the change in body weight and its composition. Body condition may be a particular problem in primiparous sows. Low lactation feed intake in these sows leads to mobilization of their body reserves for milk production. Fat and protein mobilized can vary considerably (Mullan and Williams, 1990) and this is influenced by the diet.

Several studies have shown that the addition of fat to sow diets during late gestation and/or lactation may

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increase the concentration of fat in colostrum and milk (Pettigrew, 1981; Britt, 1986).

In some experiments in literature the milk production of sows was also increased (Pettigrew, 1981; Coffey et al., 1982). In most studies the performance of sows and piglets and the composition of milk have been measured. However, only limited information is available on the energy metabolism of lactating sows when fed different levels of dietary fat.

Therefore, two experiments were conducted with primiparous sows to determine the effects of different dietary fat levels in the lactation diet on the energy- and nitrogen balances and on the efficiency of milk production and on the performance of suckling piglets.

MATERIALS AND METHODS
Experiment 1(Exp.1)

Animals. A total of 32 first litter PIC (Pig Improvement Company, England) hybrid sows were assigned to four batches of 8 animals each. One animal had to be removed from the experiment at day 14 of lactation.

Experimental Design and Diets. In two basal diets the major difference in energy sources were tapioca starh (low-fat diet: Tst) or animal fat (moderate-fat diet: A). The animal fat was slaughtering waste, packing house by-product (Nederlandse Thermo- Chemische Fabrieken, The Netherlands), (Table 1.).

Feeding and Housing. During pregnancy gilts were fed 22 MJ NE/day (2.4 kg feed/day). This energy intake level of about 1.2 times of maintenance is in accordance with recommendation of ARC (1981). This level was also chosen to prevent low feed intake during lactation. The experiment started after farrowing and lasted until weaning after 4 weeks of lactation. Sows received the experimental diets during lactation from one day after farrowing onwards. During lactation each sow was fed a maintenance level of feed, assumed to be 1 % of body weight, plus 0.4 kg per piglet for lactation (Babinszky et al., 1990, unpublished data), thus we standardized at the same energy intake.

The nutrient content of diets (apart from starch and fat) was according to the Dutch standard (CVB, 1988). Creep feed was not provided. Litter size after farrowing was standardized to 9 piglets. On day 110 of gestation each gilt was moved to a farrowing barn and placed in a farrowing crate until day 13 of lactation. Between days 14 and 27 of lactation (until weaning) the 8 sows of each batch with their piglets were assigned to two climate-respiration chambers (80 m^3 each). Sows were housed individually in metabolic cages (4 sows on the same diet with their piglets per chamber).

Table 1. Experimental arrangements
Tablica 1. Postavljanje pokusa

Exp.[a]	Treatment (Code) Postupak		
	Energy source in sows' diet Izvor energije u hrani krmača	In sows' diet (u hrani krmača) (g/kg DM)[b]	
		Starch Škrob	Fat Mast
1	Tapioca starch (Tst) Škrob tapioke	396	43
	Animal Fat (A) Životinjska mast	286	75
2	Cornstarch (Cst) Škrob kukuruza	418	37
	Animal fat (A) Životinjska mast	266	125

[a] Experiment. - Pokus
[b] Average analysed values. - Prosječno analizirane vrijednosti

Energy- and Nitrogen Balance of Sows. Measurements of the energy- and nitrogen balance of sows were made in the respiration chambers. After 4 days of adaptation to the respiration chamber, energy balances (EB) and nitrogen balances (NB) of sows were determined from energy and N in feed, feces, urine and milk over a 7 day collection period, which was between days 18 and 25 of lactation (Babinszky, 1992). Heat production (sows plus piglets per chamber) was determined indirectly by measuring of the CO_2 produced and the O_2 consumed (Verstegen et al. 1987). The heat production of sows (HP) was derived from the total heat production (sows plus piglets per chamber) by subtracting heat production of piglets (Verstegen et al., 1985).

Milk Production of Sows. Milk production of sows was measured by weghing piglets before and after various sucklings at days 16, 21 and 26 of lactation. For the calculation of milk yield, corrections for weight loss of piglets due to metabolic rate, evaporations, urinations and defecations during suckling were applied (Babinszky et al., 1992).

Estimation of Efficiency of Milk Production of Sows from Feed. We assumed that energy source (dietary fat level) had a bigger effect on efficiency than on ME need for maintenance (ME_m), because feeding level was about 4 times higher than maintenance requirement. Therefore, the efficiency of milk production from feed ME was calculated in the following way:

$$Eff_{mp} = LE / (ME_c - ME_m)$$

where: Eff_{mp} = efficiency of milk production; LE = daily lactation energy (kJ/kg$^{0.75}$); ME_c = daily ME intake corrected to zero EB; ME_m = daily maintenance requirement (420 kJ ME/kg$^{0.75}$).

Experiment 2(Exp.2)

Animals. A total of 32 first litter PIC hybrid sows were used in four subsequent batches of 8 animals each.

Experimental Design and Diets. In this experiment two basal diets (low and high fat content diets) were used (table 1.). In low fat content diet energy source was mainly cornstarch (Cst). In high fat content diet Cst (200 g/kg) was substituted by animal fat (A). The animal fat was the same product as described in exp.1. The diet with high fat was not diluted with extra crude fibre or otherwise. Therefore in the high- fat diet 0.868 kg contained the same amounts of nutrients apart from fat and starch content.

Feeding. During pregnancy gilts were fed as described in experiment 1. Daily feed ration of sows during lactation in low fat group was calculated as in experiment 1. In the high fat group sows received 86.8 % the amount of diet calculated, in this way to standardize on energy intake. Creep feed was not provided during suckling period. After parturition, the litters were standardized to 9 piglets in all batches.

Housing of Animals and Experimental Procedures. Housing of animals and experimental procedures were the same as in exp.1. Also, the measurement of EB, NB and milk production, estimation of efficiency of milk production were identical.

Statistical Analysis. Analysis of variance was done by GLM procedure (SAS, 1990) for all variables in both experiments. Details concerning statistical analysis were given by Babinszky (1992).

RESULTS AND DISCUSSION

Live Weight of Sows. The differences between treatment groups in both experiments with regard to live weight of sows post partum, at start and end of balance and at weaning were not significant.

Milk Production of Sows and Performance of Piglets. The milk yield of sows and the piglets number were also not affected by the different levels of dietary fat in sows diet. However, the daily gain of piglets in the second part of lactation was higher ($P \leq 0.05$) for piglets from sows fed high dietary fat level in exp.2. (Data are not shown).

Energy Balance of Sows. Data on energy balance are given in Table 2. The daily ME intake of sows (kJ/kg$^{0.75}$) in exp.1 was similar in both treatment groups. The energy in feces from animals fed moderate-fat diet was higher ($P < 0.05$) than from animals in the low-fat group. The energy in urine and milk and in HP was not affected by the diets. Therefore, similar (negative) energy balance was found in both experimental groups.

In exp.2 the ME intake of sows was similar to the starch and fat diets (low and high-fat diet).

The feces energy output in this experiment was also higher in the high-fat group than in the low-fat group ($P < 0.01$). The energy in urine was not affected by the diets. The milk energy production was higher in sows fed high dietary fat than those fed low-fat diet ($P < 0.05$). This higher milk energy output is a consequence of higher fat (energy) content of milk ($P < 0.05$) because the daily milk production of sows was not affected by the different dietary fat levels. Sows in the low-fat group produced more heat than in the high-fat group ($P < 0.05$). The higher feces and milk energy output in the high-fat group resulted in more negative EB than in the low-fat group ($P < 0.05$).

Kirchgessner and Müller (1984) found that, in non-pregnant, non- lactating mature sows, a high-fat diet had no effect on diet- induced thermogenesis compared to a carbohydrate-rich diet. The results of our studies with lactation diets, however, show that there is an effect on heat production from the fat-rich diet. Our results show that sows fed a high dietary fat level (exp.2) had lower energy diegstibility and a higher milk energy output. Therefore, they showed a more negative EB than animals fed the starch (low-fat) diet. At moderate-fat level (exp.1) this difference was not noted. Both in the studies of Kirchgessner and Müller (1984) and in our study the high dietary fat level substantially decrreased digestibility of energy compared to a carbohydrate-rich diet.

On the basis of the results for energy metabolism of sows the daily milk related ME intake and heat production can be calculated (Table 3).

In exp. 2. in high-fat group animals received 8 % more energy than in the low-fat group. This difference at the nearly similar ME intake can be explained by the more negative energy balance of sows in the high-fat group. The more negative EB of sows suggests that animals at controlled ME intake used more energy from body (fat) tissues than in the low-fat group. Results in Table 3 show that in exp. 1 the moderate-fat group sows produced about 5 % less heat than in the low-fat group.

Table 2. Effect of dietary fat level on the daily energy balance of sows between 18 and 25 days of lactation ($kJ/kg^{0.75}$)
Tablica 2. Djelovanje razine masti u hrani na dnevnu bilansu energije krmača između 18 i 25 dana laktacije ($kJ/kg^{0.75}$)

Item Pokazatelj	Experiment 1 Pokus			Experiment 2 Pokus		
	Energy source[a] Izvor energije			Energy source[a] Izvor energije		
	Tst	A	RMSE[b]	Cst	A	RMSE[b]
n (sows - krmača)	15	16		16	16	
GE intake - ulaz	2006	2083	203	1789	1802	125
ME intake - ulaz	1605	1626	160	1454	1404	112
Feces energy energija izmeta	349[c]	414[d]	66	294[e]	356[f]	38
Urine energy - energija mokrače	51	43	8	41	43	12
Milk energy - energija mlijeka	1073	1116	211	1019[g]	1159[h]	177
Heat production[i] -proizvodnja topline	795	779	20	771[g]	719[h]	18
Energy balance -bilansa energije	-268	-269	58	-336	-473[h]	61

a codes are defined in Table 1 - oznake su definirane na tablici 1
b Root mean square error - kvadrati pogreške artimetičke sredine
c,d Different supperscripts in the same row indicate significant differences among treatment groups in exp.1 ($P< 0.05$).
Različiti natpisi u istom redu pokazuju značajne razlike između tretiranih skupina u 1. pokusu
e,f Different supperscripts in the same row indicate significant differences among treatment groups in exp.2 ($P< 0.01$).
Različiti natpisi u istom redu pokazuju značajne razlike između tretiranih skupina u 2. pokusu
g,h Different supperscripts in the same row indicate significant differences among treatment groups in exp.2 ($P < 0.05$).
Različiti natpisi u istom redu pokazuju značajne razlike između tretiranih skupina u 2. pokusu
i Heat production of the sows = total heat production minus heat production of piglets.
Proizvodnja topline krmača = ukupna proizvodnja topline minus proizvodnja topline prasadi

Table 3. Milk related metabolizable energy intake (ME_{milk}) and heat production (HP_{milk}) of sows measured between days 18 and 25 of lactation
Tablica 3. Utrošak metaboličke energije za mlijeko (MEmlijeko) i proizvodnja topline (HPmlijeko) krmača mjerenih između 18. i 25. dana laktacije

Item Pokazatelj	Experiment 1 Pokus		Experiment 2 Pokus	
	TST[a]	A[a]	St	A
Daily ME_{milk} intake,$kJ/kg^{0.75b}$ Dnevni utrošak $ME_{mlijeka}$,$kJ/kg^{0,75\,b}$	1520	1542	1454	1575
Daily HP_{milk},$kJ/kg^{0.75c}$ Dnevni utrošak $HP_{mlijeka}$,$kJ/kg^{0,75\,c}$	377	357	363	287

a Codes are defined in Table 1. - Oznake definirane na tablici 1
b $ME_{milk} = (ME_{feed} + ME_{body}) - ME_{maintenance}$ - $ME_{mlijeka} = (ME_{hrane} + ME_{tijela}) - ME_{uzdržna}$
c $HP_{milk} = HP - ME_{maintenance}$. HP_{milk} is corrected per experiment towards similar ME intake by assuming an efficiency of body reserve into milk of 0.8.
$HP_{mlijeka} = HP - ME_{uzdržna}$. $HP_{mlijeka}$ je korigirana za pokus prema sličnom uzimanju ME podrazumijevajući učinkovitost tjelesnih rezervi u mlijeku od 0.8

In exp. 2 sows fed the high- fat diet produced 21 % less heat (HP for milk production) than those fed the low-fat diet.

Efficiency of Milk Production of Sows. In exp.1 the efficiency of milk production from ME above maintenance was not affected by the diets (Table 4). In ex.2 the efficiency was higher in the high- fat group than in the starch (low-fat) group ($P< 0.05$). The higher efficiency of milk production for sows fed the high dietary fat level may be caused by more efficient production of milk (fat) from dietary fat than from dietary starch because conversion of dietary fat to milk fat requires fewer steps than carbohydrates to milk fat (van Es and Boekholt, 1987). Noblet et al. (1990) reported that the efficiency of milk production from ME in literature ranged from 68 to 79 %, with the mean being 72 %.

This means that our data for efficiency (70-73 %) remained within the normal ranges for sows. Lellis and Speer (1983) also concluded that efficiency of milk production was higher ($P < 0.005$) for multiparous sows fed tallow than for sows fed dextrose. The results of both studies indicate that a high level of fat in the lactation diet may have a beneficial effect on the efficiency of energy in milk production.

Table 4. Effect of dietary fat level on the efficiency of milk production from feed
Tablica 4. Utjecaj razine masti u hrani na proizvodnju mlijeka

Item Pokazatelj	Experiment 1 Pokus			Experiment 2 Pokus		
	Energy source[a] Izvor energije			Energy source[a] Izvor energije		
	Tst	A	RMSE[b]	Cst	A	RMSE[b]
n (sows - krmače)	15	16		16	16	
Efficiency - učinak	0.71	0.72	0.01	0.70[c]	0.73[d]	0.01

a Codes are defined in Table 1 - Oznake su definirane na tablici 1
b Root mean square error - Kvadrat pogrješke artimetičke sredine
c,d Different supperscripts in the same row indicate significant differences among treatment groups in exp.2 ($P < 0.05$).
Različiti natpisi u istom redu pokazuju značajne razlike između tretiranih skupina u 2. pokusu ($P < 0.05$)

Nitrogen Balance of sows. The NB in both experiments was around zero and this was not influenced by the dietary fat levels (data are not shown).

In conclusion, it can be stated that feeding a high level of fat in the lactation diet causes sows to produce more milk energy ($P<0.05$) and the efficiency of milk production from ME is improved ($P < 0.05$). This improved efficiency of milk production of sows may have a favorable effect on the profitability of pig production. The data of present paper also show that sows fed a high level of dietary fat produce less heat than those fed a carbohydrate rich (low-fat) diet. Low heat production in the lactating sow can be beneficial in conditions in which heat production is a burden on the animals, especially at high ambient temperatures. Moreover, it may be beneficial by preventing a large decrease in feed intake by the sows in such conditions. The nitrogen balance and milk production were not affected by the different levels of dietary fat. The results of present study also indicate that the moderate-fat level in the lactation diet did not improve the traits tested compared to the low-fat level.

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SAŽETAK

Ukupno 63 hibridnih krmača - prvopraskinja korišteno je u dva pokusa za proučavanje djelovanja različitih razina masti u hranidbi tijekom laktacije na bilansu energije (EB), proizvodnju topline i bilansu dušika (NB) u životinja. Pokusi su upotrebljeni za mjerenje efikasnosti proizvodnje mlijeka krmača iz metaboličke energije hrane. U pokusu 1 glavna razlika u izvoru energije tijekom laktacije bila je brašno tapioke ili životinjska mast. S niskim udjelom masti hranjeno je 15 krmača (sadržaj brašna i masti: 396; 43 g/kg ST), dok je 16 krmača hranjeno hranom s umjerenim udjelom masti (sadržaj škroba i masti; 286; 75 g/kg ST) za vrijeme 4 tjedna laktacije. U pokusu 2 kukuruzno brašno (200 g/kg) bilo je zamijenjeno životinjskom mašću, te je 16 krmača hranjeno tijekom 4 tjedne laktacije hranom s niskim udjelom masti (sadržaj brašna i masti: 416; 37 g/kg ST), a 16 ih je hranjeno hranom s visokim udjelom masti (sadržaj brašna i masti: 266; 125 g/kg ST). U oba pokusa, EB i NB krmača mjereni su između 18. i 25. dana laktacije u respiracijskim komorama. Zaključeno je da su krmače hranjene visokom razinom masti u hrani proizvele više energije mlijeka i manje topline ($P < 0.05$). Učinkovitost proizvodnje mlijeka iz ME je poboljšana ($P < 0.05$) s visokom razinom masti u hrani, u usporedbi s hranom s niskom razinom masti. Životinje hranjene s većom razinom masti imale su više negativan EB ($P < 0.05$) kada je utrošak ME bio kontroliran. Na NB i prinos mlijeka nije utjecala razina masti u hrani.