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A two-diet feeding regime for lactating sows reduced nutrient deficiency in early lactation and improved milk yield ☆

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ABSTRACT

The objective of the present study was to evaluate whether a new feeding concept composed of two dietary components fed daily throughout lactation could minimize sow weight loss and increase milk yield (MY) and piglet weight gain. In total, 14 sows were included in the experiment from parturition until weaning 28 d later. The sows were fed one of two dietary feeding regimes from lactation d 2 and throughout lactation. The 1-diet feeding regime represented the Danish feeding standards and recommendations. The new 2-diet regime supplied sows feed and nutrients (ME and AA) according to their individual requirements for maintenance and milk production. Thus, a basal diet was formulated and supplied to meet the energy requirement for maintenance and a lactation supplement was formulated to meet the dynamic requirement of nutrients for milk production. Sows and piglets were weighed and feed intake was recorded weekly. In addition, weekly milk samples and blood samples on d 3 and 17 were collected. Furthermore, sows were enriched with D_2O (deuterated water) on d 2 and 28 after parturition to calculate body pools of fat and protein. Sows' feed intake and weight loss interacted with diet regime across wk of lactation. In lactation wk 4, sows fed the 1-diet feeding regime produced less milk (13.0 kg/d) than the sows fed the 2-diet regime (14.9 kg/d). Piglet weight gain was numerically higher ($P=0.11$) throughout the lactation period for sows fed the 2-diet regime. Dietary regime had no effect on milk composition of DM (dry matter), fat and protein ($P=0.99$, 0.82 and 0.94). Milk lactose content was, however, higher for sows fed the 1-diet feeding regime ($P=0.01$). Sows on both dietary regimes were in negative energy balance throughout lactation. Sows fed the 1-diet regime were negative in N and Lys and reached a positive or zero balance in late lactation. For the 2-diet feeding regime sows' N and Lys balance was positive throughout lactation, and N loss was higher for sows fed the 2-diet feeding regime. The concentration of urea in plasma was lower for sows fed the 1-diet feeding regime. In conclusion, feeding lactating sows with the 2-diet feeding regime throughout lactation improved sows' MY and mean piglet weight as lactation progressed, and sow weight loss was reduced in early lactation. By feeding sows with the 2-diet feeding regime it was also possible to reduce nutrient deficiency throughout lactation.

1. Introduction

The lactation period is an important part of the sow's reproductive cycle and is crucial for the survival of piglets. Sows' milk yield (MY) has increased during the past decades and sows are today able to produce 1.5 times their own weight in milk (Hansen et al., 2012b). Sows' MY is, however, relatively insensitive to altered supply of dietary protein or fat (Dourmad et al., 1998; Lauridsen and Danielsen, 2004).

During lactation substantial changes in nutrient supply and requirement occur, and sows mobilize great amounts of nutrients from body reserves, especially in early lactation (Theil, 2015). Typically, commercial sows lose 10–30 kg of BW during lactation even when fed ad libitum (Beyer et al., 2007; Cools et al., 2014; Smits et al., 2013), but BW loss may be even higher (Kim et al., 2009). Excessive BW loss has a detrimental effect on the subsequent reproductive cycle by e.g. delaying return to estrus (Bergsma et al., 2009; King and Dunkin, 1986; Zak et al., 1997). Furthermore, it is energetically inefficient to use body depots to support MY instead of using energy directly from feed (k=0.72–0.78; Noblet and Etienne, 1987; Theil et al., 2004). The efficiency of

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utilizing body depots (k=0.86–0.89) and restoring body condition in the subsequent gestation period (k=0.74) reduces the efficiency to approximately 0.65 to sustain MY (Noblet and Etienne, 1987; Strathe et al., 2012).

Lactating sows' are traditionally fed a single diet throughout lactation. However, the 1-diet regime is not able to take into account the changing requirements of Lys, nitrogen (N) and energy (Feyera and Theil, 2014). Sows' requirement for energy is both determined by maintenance and MY, while the Lys requirement is almost exclusively determined by MY (Theil, 2015).

We hypothesized that a feeding regime composed of two diets (a basal diet and a lactation supplement) throughout lactation could minimize sow weight loss (mobilization) and increase sow MY and piglet weight gain.

2. Materials and methods

Blood sampling, housing, and rearing were in compliance with Danish laws and regulations for the humane care and use of animals in research (The Danish Ministry of Justice, 1995). The Danish Animal Experimentation Inspectorate approved the study protocols and supervised the experiment. The health of the animals was monitored, and no illness was observed.

2.1. Animals and housing

A total of 14 cross-bred (Danish Landrace x Yorkshire) second parity sows were included in the experiment from parturition until weaning 28 d later. The experiment was carried out at Aarhus University, Foulum, Denmark in the period from April 2014 to May 2014. Sows and their litter were individually housed in fixed farrowing crates (2.7 × 1.8 m). Pen floor consists of one half concrete floor and one half iron slatted floor. Room temperature was kept around 20 °C during farrowing and then gradually reduced to 16 °C during the experimental period. The piglets had access to a heating lamp throughout the experimental period and floor heating was turned on the first 14 d after parturition. Sawdust was provided in the piglet cave before parturition. Until 48 h after parturition the light was on 24 h and in the remaining lactation period the light was on from 06 to 18 and again during feeding from 00.30 to 01.00.

2.2. Feed regime and dietary formulation

Two different feeding regimes were supplied; a traditional (1-diet feeding regime) with a standard lactation diet (control) or a 2-diet feeding regime with a basal diet and lactation supplement (2-diet feeding regime). The control diet was formulated according to Danish standards and recommendations (Tybirk et al., 2013). The 2-diet feeding regime was formulated to meet the requirements of energy, Lys and N for maintenance for gestating sows from the basal diet (NRC, 2012; Theil et al., 2004). The lactation supplement was formulated to cover the Lys and energy requirements for milk production (Feyera and Theil, 2014), while the dietary contents of other essential AA followed the recommended content relative to Lys (Tybirk et al., 2013). Inclusion levels of vitamins and minerals did not differ in the diets. The inclusion level of synthetic Lys in lactation supplement was the same as in the control diet and the CP content for basal diet and lactation supplement was dictated by the Lys content. The energy content of the basal diet was comparable to that commonly used for gestating sows, whereas the dietary energy in the lactation supplement was comparable to a standard lactation diet.

Dietary formulations of the standard lactation diet (1-diet regime) and the basal diet and lactation supplement (used in the 2-diet regime) are shown in Table 1. The energy content was elevated in the lactation supplement by addition of soybean oil. The basal diet and lactation supplement was formulated to contain the same amount of barley and wheat. The basal diet was, furthermore, formulated with a high level of dietary fiber.

Table 1
Dietary ingredients of control diet (1-diet regime), basal diet and lactation supplement (2-diet regime).

	1-diet	2-diet	
Ingredient (%)	Control diet	Basal diet	Lactation supplement
Barley	30	36.16	16.13
Wheat	43.43	36.16	16.13
Corn			30
Soybean meal	2.1		16.98
Sunflower meal	11	9.96	10.32
Rapeseed meal	5		
Oat	3		
Sugar beet pulp		3	
Alfalfa meal		3	
PFAD[1]	1.6	0.59	
Soybean oil		1	5
Calcium carbonate	1.35	1.41	1.42
Wheat bran		6.67	1.49
Sodium chloride	0.45	0.42	0.51
Monocalcium phosphate	0.55	0.07	0.94
L-Lys sulfate, 65%	0.59	0.1	0.55
Molasses	0.5	0.5	
L-Thr, 98%	0.02	0.18	0.01
Val, 40%		0.35	0.01
Vitamin E[2]	0.19	0.19	0.24
Phytase[3]	0.02	0.05	0.05
Mineral and vitamin mix[4]	0.2	0.2	0.2

[1] Palm fatty acid distillate.
[2] mg α-tocopherol.
[3] 2500 U/kg.
[4] Supplied per kilogram of diet: retinol 2 IU, α-tocopherol 63 mg, phylloquinone 4.4 mg, thiamin 2.10 mg, cyanocobalamin 0.022 mg, riboflavin 5.25 mg, pyridoxine 3.15 mg, biotin 0.44 mg, D-pantothenic acid 15.8 mg, folic acid 1.58 mg, niacin 21 mg, 15 mg Cu as $CuSO_4 \cdot 5H_2O$, 90 mg Zn as ZnO, 0.32 mg Se as Na_2SeO_3, 84 mg Fe as $FeSO_4 \cdot 7\ H_2O$, CaI 0.84 mg, 42 mg Mn as MnO.

Sows receiving the 1-diet feeding regime followed the recommended Danish feeding strategy. Thus, the 1-diet regime sows were fed 3.3 kg from lactation d 1–3, from d 4–10 the feed allowance increased by 0.5 kg per d, and increased by 0.2 kg from d 11–20, reaching a plateau of 9 kg/d from d 20 until weaning. On average, 1-diet sows received 4.0, 6.7, 8.2, and 8.8 kg/d in week 1, 2, 3, and 4, respectively. In contrast, the feeding level employed for sows fed the 2-diet feeding regime was based on amount of energy (ME) required by individual sows. Energy required for maintenance was calculated as metabolic live weight ($kg^{0.75}$) × 482 $kJ/kg^{0.75}$, as reported by Theil et al. (2004) and this part of the energy requirement was covered by the basal diet (on average 2.25 kg/d was supplied throughout lactation). The energy required for milk production was calculated based on a forecast of the expected MY, multiplied with average energy content of milk at a specific day of lactation (Hansen et al., 2012b), and the efficiency of utilizing ME for milk production (k_L=0.78; Theil et al., 2004). The energy requirement was initially covered with 70% of requirement on d 2, and it increased by 2% units daily because a previous experiment with sows fed a 2-diet regime performed better if they started 30% below their energy requirement (Feyera and Theil, 2014). Thus, in addition to the basal diet, the 2-diet sows received on average 2.8, 4.9, 5.9 and 6.0 kg/d in wk 1, 2, 3, and 4, respectively. The feeding curves for 1-diet and 2-diet sows are shown in Fig. 1.

Feed was provided automatically three times daily at 00.30, 08.30 and 16.30 h. Sows had free access to water. No straw was