L-Carnitine helps sows to mobilise fat as energy

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Recent studies in fattening pigs have shown that L-Carnitine reduces body fat deposition and increases protein accretion. These effects are due to an increased rate of β-oxidation and increased re-utilisation of waste nitrogen for protein synthesis by dietary L-Carnitine.

Lactating sows are usually unable to consume enough feed to fully provide the enormous amount of nutrients they need for milk production.

To do this they mobilise energy and amino acids from body reserves, namely the body fat and body protein and use these to produce milk. Based on our studies in growing pigs, we hypothesise that L-Carnitine supplementation favours the mobilisation of energy from adipose tissue which can be used to produce surplus milk.

We further hypothesise that an increased utilisation of body fat might reduce catabolism of body protein under a negative nitrogen balance.

To test these hypotheses, we performed a trial with sows which were fed basal diets low in energy and protein to induce a strong negative energy and nitrogen balance and to promote mobilisation of energy from body reserves.

To establish if there was any relationship between mobilisation of body reserves (body fat and body protein) and milk production, we also measured milk production at days 11 and 18 and litter growth during lactation in order to calculate the sows' energy balance.

Despite the somewhat unusual study design we think the L-Carnitine related findings are of interest to both researchers and practitioners.

Materials and methods

In this study, 24 crossbred sows (German Landrace x Large white) in their third reproductive cycle and with an average body weight of 208kg were assigned to two groups of 12 animals each.

Their sexual cycle was synchronised by the oral administration of 20mg altrenogest (Regumate) a day. The sows were artificially inseminated with sperm from Pietrain boars. Finally, eight pregnant sows were randomly selected from each group to take part in this experiment.

The sows were kept in single crates until day 30 of pregnancy. From day 30 to 110 of pregnancy, the sows were kept in groups of eight in pens measuring 45m² which had fully slatted floors, nipple drinkers and electronic feeding stations.

Table 1. Feed intake, body weight and backfat thickness.

Treatment	Control	Plus L-Carnitine	L-Carnitine effect (P)
Number of sows	8	8	
Feed intake (kg/d)			
Pregnancy	3.5	3.9	NS
Lactation	4.6	4.7	NS
Body weight (kg)			
Day one of pregnancy	202	211	NS
At farrowing	257	260	NS
At weaning	194	194	NS
Backfat thickness (mm)			
Day one of pregnancy	17.9	18.6	NS
At farrowing	23.4	25.3	NS
At weaning	12.4	9.6	<0.05

NS = not significant (P>0.05)

Treatment	Control	Plus L-Carnitine	L-Carnitine effect (P)
Number of sows	8	8	
Number of piglets born	12.2	12.3	NS
Number of piglets born alive	12.1	12.3	NS
Weight of piglets at birth (kg)	1.55	1.65	NS
Weight of litters at birth (kg)	17.9	20.1	NS
Weight of litters at weaning (kg)*	92.0	108.1	<0.001
Litter gain during lactation (kg)*	76.1	91.2	<0.001

**Litters were standardised to 10 piglets. NS = not significant (P>0.05)*

Table 2. Number of piglets, weight of piglets and litters at birth and litter gains during lactation.

native L-Carnitine in the diet was 20mg/kg. From the beginning of the experiment until day 30 of pregnancy the sows were given 3.0kg of gestation diet per day; from day 30 to day 110 the diet was offered for ad libitum consumption.

From day 110 to farrowing each sow was fed 2.5kg of lactation diet. On the day of farrowing the sows were fed 1.5kg/d, which was then successively increased (3kg/d on day one and day two of lactation; 4.5kg/d on day three and day four of lactation; ad libitum consumption from day five of lactation to weaning).

The sows of the treated group received a supplement of 125mg L-Carnitine (Carniking) per head and day during pregnancy and 250mg L-Carnitine per head and day during lactation. The supplements were supplied as tablets. Water was provided by nipple drinking systems. Piglets were weaned on day 30 after farrowing. Milk output was determined on day 11 and day 18 of lactation in eight sows from each group.

Treatment	Control	Plus L-Carnitine	L-Carnitine effect (P)
Number of sows	8	8	
Milk production (kg/d)			
Day 11	7.76	9.06	<0.05
Day 18	8.74	10.43	<0.05
Nutrients secreted with milk on day 11 (g)			
Fat (g)	745	865	NS
Protein (g)	385	442	NS
Lactose (g)	428	504	NS
Gross energy (MJ)	45.0	52.2	NS

NS = not significant (P>0.05)

Table 3. Milk production at day 11 and day 18 and amounts of nutrients secreted with milk at day 11 of lactation.

On day 110 of gestation, they were moved to the farrowing accommodation where they were housed in single farrowing pens. One basal diet was used throughout pregnancy and lactation.

The diet contained 9.0 MJ of metabolisable energy/kg.

Concentrations of nutrients in the diets were (g/kg diet): crude protein, 144; crude fibre, 131; crude fat, 27; starch, 182; sugar, 64; lysine, 6.4; methionine, 2.1; threonine, 4.7; tryptophan, 1.5.

Nutrient concentrations conformed to recommendations for pregnant sows; concentrations of energy and essential amino acids were considerably below the levels recommended for lactating sows (National Research Council 1998). The concentration of

In order to eliminate the effect of litter size on milk production, litter sizes were standardised to 10 piglets/litter within two days of farrowing. Milk output was measured by the 'weigh-suckle-weigh' method.

To obtain milk for analysis, on day 11 of lactation the sows were given 15 IU oxytocin by intramuscular injection after their milk output had been measured. Some 80-100mL of milk was harvested

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manually from all the active teats of each sow. Backfat thickness was measured by vertically positioning the probe of an ultrasound machine 5cm left of the spinal column, level with the 13th/14th rib.

To estimate how much fat and protein were lost during lactation, the amounts of body fat and body protein were estimated from body weight and backfat thickness in accordance with the regression equations for predicting the body composition of sows (CVB 1994).

To estimate the sows' energy balance during lactation, we used the model equations for predicting swine requirements ('lactation model') published by the National Research Council (1998).

Results

There was no significant difference in the feed intake of the control sows and the sows supplemented with L-Carnitine during pregnancy and lactation (Table 1); nor was there any difference in the body weights of the control sows and sows supplemented with L-Carnitine on day one of pregnancy, after farrowing and at weaning.

The sows in both groups lost a lot of weight during lactation, but the losses were similar in both groups (62.4 ± 13.7 in control sows vs. 65.8 ± 13.4kg in sows supplemented with L-Carnitine).

There was no significant difference in the backfat thickness of the control sows and sows supplemented with L-Carnitine on day one of pregnancy and on the day of farrowing.

Backfat thickness at weaning, however, was significantly lower in the sows treated with L-Carnitine than in the control sows.

The reduction in backfat thickness between the day of farrowing and the day of weaning was greater in the sows supplemented with L-Carnitine than in the control sows (16.0 vs. 11.0 mm, P<0.05).

Number and weights of piglets

There was no difference between the control sows and the sows supplemented with L-Carnitine in terms of total litter size and the number of piglets born alive (Table 2).

Mean piglet and litter weights at birth were slightly higher in the L-Carnitine supplemented sows than in the control sows.

The litters of the sows supplemented with L-Carnitine gained more body weight during the 29-day suckling period and were heavier at weaning than the litters of the control sows.

Treatment	Control	Plus L-Carnitine	L-Carnitine effect (P)
Number of sows	8	8	
Energy intake by diet (MJ ME)	1192	1236	NS
Energy requirement for maintenance (MJ)	742	746	NS
Energy requirement for milk production (MJ)	1740	2100	<0.01
Energy balance (MJ)	-1290	-1610	<0.01

NS = not significant (P>0.05)

Table 4. Estimated energy balance during lactation.

Milk output and milk nutrients

Milk output on day 11 and day 18 of lactation was significantly higher in the sows treated with L-Carnitine than in the control sows (Table 3).

The quantities of fat, protein, lactose and energy secreted in the milk were 15-18% higher in the sows supplemented with L-Carnitine than in the control sows.

Estimated energy balance

There was no difference between the two groups of sows in terms of dietary energy intake and estimated energy requirement for maintenance throughout lactation (Table 4). However, the sows supplemented with L-Carnitine required more energy for milk production and displayed a higher total energy requirement.

The energy balance of both groups was strongly negative, although this was more pronounced in the sows supplemented with L-Carnitine than in the control sows.

Estimated losses

The estimated amounts of fat and protein in the body on day one of lactation were similar in both groups of sows (Table 5).

The estimated loss of body fat during lactation was higher in the sows supplemented with L-Carnitine than in the control sows, while the estimated loss of protein was even slightly lower in the sows supplemented with L-Carnitine than in the control sows.

The sows supplemented with L-Carnitine, therefore, had less body fat at weaning than the control sows, while body protein levels did not differ. The estimated ratio of body fat to body protein at weaning was thus lower in the sows supplemented with L-Carnitine than in the control sows.

The estimated losses of adipose tissue plus lean mass in both groups of sows were similar to the observed body weight losses.

Table 5. Estimated amounts and losses of body fat, body protein, adipose tissue and lean tissue and energy mobilised during the lactation period.

Treatment	Control	Plus L-Carnitine	L-Carnitine effect (P)
Number of sows	8	8	
Body fat (kg)			
Amount on day one of lactation	59.3	63.2	NS
Amount at weaning	31.9	26.0	<0.05
Body protein (kg)			
Amount on day one of lactation	38.5	38.5	NS
Amount at weaning	31.3	32.2	NS
Ratio body fat/body protein (kg/kg)			
Day 1 of lactation	1.54	1.65	NS
Weaning	1.03	0.81	<0.05
Losses during lactation (kg)			
Body fat	27.4	37.2	<0.05
Body protein	7.2	6.3	NS
Adipose tissue	30.4	41.4	<0.05
Lean mass	31.5	27.3	NS
Adipose tissue + lean mass	61.9	68.7	NS
Energy mobilised during lactation (MJ)			
From body fat	1078	1467	<0.05
From body protein	170	148	NS
Total	1248	1614	<0.05

NS = not significant (P>0.05)

Conclusion

This study shows that sows supplemented with L-Carnitine are able to mobilise more energy from adipose tissue during lactation when there is a strong negative energy balance than control sows.

The energy balance shows that the surplus energy mobilised in sows supplemented with L-Carnitine was used to produce surplus milk. The production of surplus milk by the L-Carnitine supplemented sows might be the reason for the higher growth rates of their suckling piglets.

It is well known that even a mild restriction of energy intake can cause a considerable reduction in milk yield.

It is noteworthy that the sows supplemented with L-Carnitine had high milk yields and fast growing litters despite the strongly negative energy balance.

Although the sows supplemented with L-Carnitine transferred more protein to their piglets in their milk, they mobilised even less body protein during lactation than the control sows. This means that L-Carnitine also improved the efficiency of body protein utilisation for milk synthesis.

In sows, considerable energy deficiency and loss of body mass may also occur during lactation in real life situations, particularly in primiparous sows.

The present study suggests that in such situations, dietary L-Carnitine may help sows to maintain a high milk yield and fast suckling litter growth.

Recommended supplement

The large body of research results suggests that permanent L-Carnitine supplementation produces the best response in reproducing sows.

The recommended level is 50mg L-Carnitine per kg of feed. Gilts should start to receive supplements when they are being introduced into the sow herd. n