

# Effect of L-carnitine Supplementation in Gestating and Lactating Diets on Sow Performances

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## ABSTRACT

An on- farm feeding trial was conducted to investigate the effect of L-carnitine supplementation in gestating and lactating diets on total litter weight (TLW) and performances of sows from farrowing to weaning. Thirty Large White x Landrace (LWLR) sow (parity 3-5) consisting of 15 animals each in the treatment and the control groups were included in the study. The feeding trial started 24 days after mating and pregnancy confirmation was conducted by ultra-sound scanning. During gestation, the treatment groups were supplemented with L-carnitine (LCS) at 150 mg /sow/day and during lactation at 350 mg /sow/day. The control sows (C) received normal farm diet. As compared to C diets, LCS diets had a significant increase ( $P < 0.01$ ) in TLW at  $12 \pm 1$  h (TLW<sub>12</sub>) and at  $36 \pm 1$  h (TLW<sub>36</sub>) after farrowing and at weaning (TLW<sub>w</sub>). No significant effect ( $P > 0.05$ ) of LCS diet was observed on number born alive (NBA). However, a significant decrease ( $P < 0.03$ ) was found on number of stillborn (SB) piglets as compared to C diet. Significant increases ( $P < 0.04$ ) in pre-weaning survival (PWS) of litters and litter size at weaning (LS<sub>w</sub>) were found in the sows fed on LCS diets as compared to those fed on C diets. In addition, a significant increased ( $P < 0.02$ ) in back fat (BF) thickness at farrowing was observed in sows fed on LCS diet compared to those fed on C diet. In conclusion, LCS diets have a beneficial effect on increasing TLW and sow performances under commercial farm conditions.

**Key words:** L-carnitine, sow diet, piglets

## INTRODUCTION

Appropriate and balance feeding during gestation and lactation would affect herd productivity through litter performance while adequate energy intake during gestation and lactation is essential for maximum reproductive efficiency in swine breeding herds (Coffey *et al.*, 1994). The increased dietary nutrient utilization by lactating sow could result in improvement of milk for the litters to nurse for attaining early litter weaning weight. A sow with good body condition

is expected to produce large quantity of milk without much loss of body tissue reserves. L-carnitine is a vitamin like water soluble compound that is required in the process of fatty acids transportation across the mitochondria membrane where they are processed to generate energy (DeRouche *et al.*, 2005). It is widely accepted that L-carnitine plays a vital role in fatty acid metabolism (Elder *et al.*, 2001). Moreover, as L-carnitine plays a major role in  $\beta$ - oxidation of fatty acids, it is increasingly used in livestock feed industry in the recent years. Research works by

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Musser *et al.* (1999) indicated that L-carnitine supplementation during gestation and lactation in the sows resulted in reduced stillborn piglets, increased number born alive, number weaned and piglet weight at birth and at weaning.

L-carnitine supplementation could improve sow and litter performance through increased milk production and improved weaning performance of piglets (Ramanau *et al.*, 2005). Besides, litters from sows supplemented with L-carnitine gained more weight and were heavier at weaning compared to those from control sows. The endogenous synthesis of L-carnitine in sows does not cover the amount required for maximum performance during pregnancy and lactation (Eder, 2005). Wider understanding regarding the function of L-carnitine supplementation in gestating and lactating diets and its potential in improving total litter weight of piglets from farrowing to weaning has not been proved. Thus, it is imperative to explore this under on-farm condition in order to optimize productivity of sow through litter performance. Therefore, the objective of this study was to investigate the effect of L-carnitine supplementation in the sow gestation and lactation diets on total litter weight and sow performance from farrowing to weaning.

## MATERIALS AND METHODS

### Gestation housing, feeding and management

A feeding trial was conducted at Trang Wattana (about 1,800 sows on farm), Southern Thailand from March to July, 2006. Thirty LWLR sows (parity 3-5) were selected 24 days after mating and pregnancy confirmation by ultra-sound scanning. During gestation, these sows were raised in an intensive housing with an open building in the individual gestation stall (2.4 m × 0.8 m) and slatted floor. Each house had four fans located at strategic points which provided ventilation in the shed. Water-drip cooling system on the shoulder of the sows was used to reduce heat stress and

maintain their body temperature during hot weather. The feeding trial started 24 days after mating and the main treatment consisted of normal farm diet (C) and the diet supplemented with L-carnitine (LCS). Fifteen sows were included in each treatment group in two batches.

Fifteen sows of treatment group were supplemented with L-carnitine as topped up once a day in their gestation diet at 50 mg/kg feed/sow/day. Each animal, therefore, received approximately 150 mg of L-carnitine in their daily diet corresponding to average daily feed intake of about 3 kg/sow/day. The sows in C group received control diet with average daily feed intake of about 3 kg/sow/day. These sows were fed twice a day in the morning (5.30 am) and in the afternoon (1 pm). Each sow had individual feeder and a nipple drinker which provided an adequate access to drinking water. The farm followed routine vaccination schedule as a prophylactic measures. All sows in the gestation units received same level of farm management practices excepting the feeding regime. After 16<sup>th</sup> week of gestation, one week before the expected day of farrowing, the sows were moved to farrowing shed.

### Lactation housing, feeding and management

In the farrowing shed, the sows were raised in an intensive housing with an open building type in an individual farrowing crate with a slatted floor (2.5 m × 2.0 m) having a provision for piglet rearing. In addition, each shed had four ventilation fans operated during the day to provide fresh air and a water- drip cooling system to maintain their body temperature. The sow had free access to individual feeder and a nipple drinker. One week before the expected date of farrowing, the sows were fed lactation diet at 2 kg/sow/day in the morning (6.30 am) and in the afternoon (3.30 pm). The sows were also topped up with wheat bran or rice polished at 1kg/sow/day for proper bowel movement and to reduce constipation at the time of farrowing.

All sows were administered with synthetic Prostaglandin  $F_{2\alpha}$  one day before farrowing as a routine procedure. The antibiotics and antipyretic drugs were administered when they started farrowing and oxytocin was given once farrowing was over. On the day of farrowing (Day 0), the sows were not given any feed but they had adequate access to drinking water. On Day 1, the sows were fed at 1 kg/sow/day and gradually increasing up to 5 kg/sow/day until Day 5. From Day 6 onwards until weaning, all the sows were fed *ad libitum* at 6.30 am, 10.30 am, 3.30 pm and 8 pm. The average individual daily feed intake of sow in LCS group was 6.7 kg and sow from C group was 6.3 kg from Day 6 onwards. During lactation, L-carnitine was topped up at 50 mg/kg feed/sow/day. Each animal therefore received 350 mg of L – carnitine in their daily diet corresponding to their average daily feed intake of about 6.7 kg/sow/day. The routine vaccination program was followed in both LCS and C sow groups.

More than 12 piglets were taken away from sow and litter size (LS) was standardized to twelve piglets each few hours *post partum* in both groups. Litter had an access to creep box with 100 Watt bulb hanging above the creep area to maintain temperature inside creep box. The litters had access to creep feed from Day 10 after farrowing until weaning. The litters were weaned on an average 24 days after farrowing. Routine management practices like trimming of milk teeth, ear notching, tail docking, and castration of male piglets including iron and antibiotic injections was followed. All sows and piglets in the lactation house were subjected to normal farm management practices except feeding regime. The ingredients used and their nutrient levels in gestation and lactation diets are indicated in Table 1 and 2.

#### Records on production performances

Total litter weight (TLW) and litter size (LS) at  $12 \pm 1$  hour (TLW12 and LS12) and at 36

**Table 1** Compositions of experimental diets.

Item ( kg/ton feed)	Gestation diet	Lactation diet
Broken rice	50.00	390.00
Corn	150.00	0.00
Cassava meal	350.00	0.00
Soybean oil	12.00	25.00
Rice polished	170.00	200.00
Rice polished (solvent extracted)	20.00	0.00
Soybean meal (44%)	200.00	180.00
Full fat Soya	0.00	125.00
Fish meal (65%)	10.00	30.00
L- Lysine	0.00	1.70
DL- Methionine	0.70	1.70
L- Threonine	0.30	0.60
Mono- dicalcium phosphate ( P21)	17.00	14.00
Calcium carbonate	12.00	13.00
Salt	3.00	3.00
Premix breeder	2.50	2.50
Protorsan®	0.00	20.00

<sup>1</sup> Premix breeder: A commercial feed additives.

® Protorsan: An amino acids by-products retrieved from [www.lindos.it/PROTORSAN.htm](http://www.lindos.it/PROTORSAN.htm).

± 1 hour (TLW36 and LS36) after farrowing and at weaning (TLWw and LSw) were recorded from individual sow from both groups. TLW12 and LS12 were taken from the time the last piglet was born until 12 hours. TLW was calculated by taking weight of all live piglets together using weighing balance. The number born alive (NBA), stillborn (SB), and pre-weaning survival (PWS) of litters were recorded from both groups. The back fat (BF) thickness in sows at farrowing and at weaning were recorded from both groups using Renco, lean-meter, digital back fat indicator at 10<sup>th</sup> -12<sup>th</sup> rib, 5-7 cm off the midline. Diet with and without LCS were considered as main treatments. The parity and barn were considered as other minor effects. The model used in the study was a fixed model. The main traits considered in the model were TLW12 and TLW36 and TLWw. Other minor traits were SB, NBA, LS12, LS36, LSw, PWS of litters and sow BF thickness.

### Statistical analysis

Data were analyzed in Randomized Completely Block Design (RCBD) using PROC General linear model (GLM) procedure in Statistical Analysis System (SAS, 1999). Duncan's

Multiple Range Test was used for mean comparison according to Cody and Smith (1997). The results on production parameters and on sow BF thickness are presented as Least Square Means (LSM) and Standard Errors (SE).

### The statistical model used was:

$$Y_{ijklm} = \mu + \text{Diet}_i + \text{Parity}_j + \text{Barn}_k + \text{Diet*Parity}_{ij} + \text{Diet*Barn}_{ik} + \text{Parity*Barn}_{jk} + \text{Diet*Parity*Barn}_{ijk} + \text{Period}_l + e_{ijklm}$$

The terms of the model were:

$Y_{ijklm}$  = dependent variables

$\mu$  = overall mean

$\text{Diet}_i$  = Fixed effect of  $i^{\text{th}}$  treatment ( $i$ = control, L-carnitine)

$\text{Parity}_j$  = Fixed effect of  $j^{\text{th}}$  parity ( $j$ = 3, 4, 5)

$\text{Barn}_k$  = Fixed effect of  $k^{\text{th}}$  barn ( $k$ = 1, 2)

$\text{Diet*Parity}_{ij}$  = effect of  $ij^{\text{th}}$  interactions of diet\*parity

$\text{Diet*Barn}_{ik}$  = effect of  $ik^{\text{th}}$  interactions of diet\*barn

$\text{Parity*Barn}_{jk}$  = effect of  $jk^{\text{th}}$  interactions of parity\*barn

**Table 2** Nutrient compositions of experimental diets by calculation in dry matter (DM) basis.

Item	Gestation diet	Lactation diet
Metabolizable energy (K cal/kg)	3,052.54	3,248.55
Protein (%)	14.34	21.44
Fat (%)	4.99	8.80
Fibre (%)	5.01	4.31
Calcium (%)	0.96	0.96
Total Phosphorus (%)	0.87	0.93
Available Phosphorus (%)	0.44	0.44
Salt (%)	0.37	0.32
L- Lysine (%)	0.76	1.26
Methionine + Cystine (%)	0.49	0.80
Methionine (%)	0.29	0.53
L- Threonine (%)	0.55	0.85
Tryptophan (%)	0.17	0.25
Valine (%)	0.00	1.09

Diet\*Parity\*Barn  $_{ijk}$  = effect of  $ijk^{\text{th}}$  interactions of diet\*parity\*barn

Period<sub>l</sub> = effect of  $l^{\text{th}}$  block ( $l = 1, 2$ )

$e_{ijklm}$  = Random error  $\sim$  NID (0,  $\sigma^2$ )

## RESULTS

### Effect of L-carnitine supplemented diets on performance parameters

LCS in sow gestation and lactation diets had significant increases ( $P < 0.01$ ) in TLW12 and TLW36 after farrowing and TLWw when compared to C diet (Table 3). No significant effect ( $P > 0.05$ ) of LCS diet was found on number of piglets born alive. However, a significant effect ( $P < 0.03$ ) of LCS diet was found on number of SB

piglets when compared to C diet. Likewise, a significant increase ( $P < 0.04$ ) in PWS survival of litters was found in sows with LCS diet compared to C diet. Moreover, a significant effect ( $P < 0.04$ ) of LCS diet was found on LSw when compared to C diet.

### Effect of L-carnitine supplemented diets on sow back fat thickness

A significant increase ( $P < 0.02$ ) in BF thickness of sows was observed at farrowing in LCS group compared to C group. However, no significant effect ( $P > 0.05$ ) of LCS diet was found in BF thickness at weaning and changes in their BF thickness from farrowing and weaning (Table 4).

**Table 3** Least square means  $\pm$  Standard errors of production parameters between LCS and C groups (n= 15).

Performance parameters	Treatment group (+ L-carnitine)	Control group (- L-carnitine)	P values
NBA ( heads)	12.40 $\pm$ 0.52	12.06 $\pm$ 0.52	0.650
SB ( heads)	00.07 $\pm$ 0.14	00.53 $\pm$ 0.14	0.030
TLW12 (kg)	19.56 $\pm$ 0.21	17.55 $\pm$ 0.21	0.010
TLW36 (kg)	22.41 $\pm$ 0.27	19.95 $\pm$ 0.27	0.010
TLWw (kg)	79.40 $\pm$ 2.04	68.37 $\pm$ 1.90	0.010
PWS (%)	95.66 $\pm$ 1.83	90.07 $\pm$ 1.90	0.040
LS12 (heads)*	12.00 $\pm$ 0.00	12.00 $\pm$ 0.00	0.000
LS36 (heads)	12.00 $\pm$ 0.64	11.87 $\pm$ 0.64	0.150
Lsw (heads)	11.47 $\pm$ 0.21	10.80 $\pm$ 0.21	0.040

\*LS standardized to 12 piglets between LCS and C sow groups few hours *post partum*

n = number of animals in each group

**Table 4** Least squares means  $\pm$  Standard errors of sow back fat thickness between LCS and C groups (n = 15).

Period	Treatment group (+ L-carnitine)	Control group (- L-carnitine)	P values
At start (mm)	19.33 $\pm$ 0.61	19.00 $\pm$ 0.61	0.70
At farrowing ( mm)	20.33 $\pm$ 0.28	19.33 $\pm$ 0.28	0.02
At weaning ( mm)	16.87 $\pm$ 0.29	16.20 $\pm$ 0.29	0.12
Changes (farrow to wean (mm))	-03.47 $\pm$ 0.23	-03.13 $\pm$ 0.23	0.31

n = number of animals in each group

**Effect of parity on TLW**

The result indicated that parities had a significant effect ( $P < 0.01$ ) on TLW at weaning. However, it did not show any effect ( $P > 0.05$ ) on TLW12 and TLW36 after farrowing (Table 5).

**Effect of barn on TLW**

The result showed that barn did not have any significant effect ( $P > 0.05$ ) on TLW12 and

TLW36 after farrowing and TLWw (Table 6).

**Interactions effects on TLW**

No significant interactions effects ( $P > 0.05$ ) of diet\* parity, diet\*barn, parity\*barn and diet\*parity\*barn were observed on TLW12 and TLW36 after farrowing and TLWw (Table 7, 8, 9 and 10).

**Table 5** The effect of parity on TLW (LSM  $\pm$  SE).

Parity no	TLW12 (kg)	TLW36 (kg)	TLWw (kg)
3	18.15 $\pm$ 0.23 <sup>a</sup>	20.58 $\pm$ 0.30 <sup>a</sup>	67.57 $\pm$ 2.27 <sup>b</sup>
4	18.57 $\pm$ 0.32 <sup>a</sup>	21.28 $\pm$ 0.42 <sup>a</sup>	76.65 $\pm$ 3.14 <sup>a</sup>
5	18.94 $\pm$ 0.23 <sup>a</sup>	21.68 $\pm$ 0.30 <sup>a</sup>	77.43 $\pm$ 2.28 <sup>a</sup>

<sup>a, b</sup> Least square means in the same column with different superscripts differ significantly ( $P < 0.01$ ).

**Table 6** The effect of barn on TLW (LSM  $\pm$  SE).

Barn no	TLW12 (kg)	TLW36 (kg)	TLWw (kg)
1	18.59 $\pm$ 0.21	21.30 $\pm$ 0.28	73.79 $\pm$ 2.09
2	18.52 $\pm$ 0.21	21.06 $\pm$ 0.28	73.98 $\pm$ 2.09

**Table 7** Effect of diet and parity interactions on TLW (LSM  $\pm$  SE).

Diet	Parity no	TLW12 (kg)	TLW36 (kg)	TLWw (kg)
LCS	3	18.96 $\pm$ 0.44	21.54 $\pm$ 0.40	71.28 $\pm$ 3.16
LCS	4	19.29 $\pm$ 0.35	22.04 $\pm$ 0.57	79.40 $\pm$ 4.47
LCS	5	20.23 $\pm$ 0.33	23.43 $\pm$ 0.42	85.95 $\pm$ 3.30
C	3	17.29 $\pm$ 0.31	19.54 $\pm$ 0.40	63.44 $\pm$ 3.16
C	4	17.85 $\pm$ 0.44	20.50 $\pm$ 0.57	79.29 $\pm$ 4.45
C	5	17.64 $\pm$ 0.31	20.01 $\pm$ 0.40	69.37 $\pm$ 3.11

LCS = L-carnitine supplemented diets

C = Control diets

**Table 8** Effect of diet and barn interactions on TLW (LSM  $\pm$  SE).

Diet	Parity no	TLW12 (kg)	TLW36 (kg)	TLWw (kg)
LCS	1	19.83 $\pm$ 0.28	22.78 $\pm$ 0.38	80.37 $\pm$ 2.93
LCS	2	19.29 $\pm$ 0.30	22.04 $\pm$ 0.40	78.43 $\pm$ 3.03
C	1	17.37 $\pm$ 0.29	19.84 $\pm$ 0.39	67.32 $\pm$ 2.95
C	2	17.73 $\pm$ 0.27	20.06 $\pm$ 0.37	69.43 $\pm$ 2.86

LCS = L-carnitine supplemented diets

C = Control diets

**Table 9** Effect of parity and barn interactions on TLW (LSM  $\pm$  SE).

Parity no	Barn no	TLW12 (kg)	TLW36 ( kg)	TLWw (kg)
3	1	17.81 $\pm$ 0.38	20.71 $\pm$ 0.51	63.18 $\pm$ 3.72
3	2	18.31 $\pm$ 0.27	20.21 $\pm$ 0.36	69.80 $\pm$ 2.63
4	1	18.98 $\pm$ 0.45	21.84 $\pm$ 0.59	80.07 $\pm$ 4.34
4	2	18.17 $\pm$ 0.45	20.71 $\pm$ 0.59	73.22 $\pm$ 4.36
5	1	19.03 $\pm$ 0.27	21.87 $\pm$ 0.36	78.16 $\pm$ 2.66
5	2	18.81 $\pm$ 0.39	21.41 $\pm$ 0.52	75.92 $\pm$ 3.84

**Table 10** Effects of diet, parity and barn interactions on TLW (LSM  $\pm$  SE).

Diet	Parity no	Barn no	TLW12 (kg)	TLW36 ( kg)	TLWw (kg)
LCS	3	1	18.50 $\pm$ 0.48	21.10 $\pm$ 0.62	66.51 $\pm$ 4.95
LCS	3	2	19.20 $\pm$ 0.34	21.75 $\pm$ 0.44	73.91 $\pm$ 3.50
LCS	4	1	19.67 $\pm$ 0.69	22.02 $\pm$ 0.90	77.84 $\pm$ 7.16
LCS	4	2	19.10 $\pm$ 0.48	22.00 $\pm$ 0.62	80.91 $\pm$ 4.95
LCS	5	1	20.55 $\pm$ 0.30	23.80 $\pm$ 0.40	87.57 $\pm$ 3.13
LCS	5	2	18.94 $\pm$ 0.68	21.78 $\pm$ 0.89	76.39 $\pm$ 7.12
C	3	1	17.10 $\pm$ 0.48	19.30 $\pm$ 0.61	59.71 $\pm$ 4.95
C	3	2	17.40 $\pm$ 0.34	19.65 $\pm$ 0.44	65.56 $\pm$ 3.50
C	4	1	18.14 $\pm$ 0.49	21.18 $\pm$ 0.64	78.79 $\pm$ 5.13
C	4	2	17.27 $\pm$ 0.69	19.22 $\pm$ 0.89	62.24 $\pm$ 7.16
C	5	1	17.16 $\pm$ 0.39	19.47 $\pm$ 0.51	66.02 $\pm$ 4.08
C	5	2	18.11 $\pm$ 0.39	20.53 $\pm$ 0.51	72.61 $\pm$ 4.06

LCS = L-carnitine supplemented diets

C = Control diets

## DISCUSSION

### Effect of L-carnitine supplemented diets on TLW

The findings from the current study indicated that LCS in sow gestation and lactation diets had a significant effect on TLW12 and TLW36 after farrowing and TLWw compared to control diet. Possibly, L-carnitine supplementation during this period may lead to improved dietary nutrient utilization in the sows resulting in heavier litters from farrowing to weaning. Moreover, in the current study LCS sows might have partitioned greater amount of their body energy reserves into milk production compared to C sows in raising and weaning heavier litters. Similarly, the daily

milk production from sows during lactation period could be positively correlated to TLW. The findings of this study is in line with Musser *et al.* (1999); Eder *et al.* (2001); Ramanau *et al.* (2002) and Ramanau *et al.* (2004) who found out that LCS in sow gestation and lactation diets resulted in heavier litters at birth and at weaning compared to control diet. In addition, their study showed that piglets of sows fed diet supplemented with L-carnitine grew faster during the suckling period than piglets of control sows. Higher TLW12 and TLW36 after farrowing and TLWw of piglets in LCS group in this study may indirectly confirm this.

Sows supplemented with L-carnitine produced more milk during lactation period than

the control sows (Ramanau *et al.*, 2005). The amount of fat, protein, lactose and energy secreted in milk was also 15 to 18% higher in the sows supplemented with L-carnitine than in the control sows (Ramanau *et al.*, 2005). The results in this study also show that LCS sows could have increased quality and quantity of milk as their litters were bigger and put on weight faster than those from C sow group. The sows supplemented with 125 mg of L-carnitine per day during gestation and 250 mg per day during lactation produced 18% more milk and their litters' gain 20% more weight during the suckling period than control sows (Eder, 2005; Ramanau *et al.*, 2005). Similarly, Ramanau *et al.* (2004) confirmed that improvement in growth and performance of litter is the reflection of increased milk production in sows whose diets was supplemented with L-carnitine.

Higher litter weight gain as well as individual piglet weight gain was found from sows whose diet was supplemented with L-carnitine than that of control diet (Eder *et al.*, 2001). In addition, their findings showed that heavier TLW at birth (15.4 kg vs. 14.4 kg) and TLWw (74.1 kg vs. 67.6 kg) were from LCS diet compared to C diet. Similarly, the present study indicated that TLW12 and TLW36 after farrowing and at TLWw of the piglets from LCS were heavier than that of control. Likewise, Ramanau *et al.* (2004) found that piglets of sows supplemented with L-carnitine gained more weight during the suckling period although they were initially lighter than piglets of control sows. In fact, piglets from sows supplemented with L carnitine were more vigorous and despite their lower initial body weight, they were able to stimulate greater milk flow in the sows than piglets from control sows (Ramanau *et al.*, 2004). In addition, higher growth rates of piglets may partly be due to an increased in supply of nutrients in the milk and higher milk production (Ramanau *et al.*, 2004). In current study, the TLW12 and TLW36 after farrowing and TLWw

were higher in LCS group compared to C group. This could be due to the effect of L carnitine on dietary nutrient utilization in sow and partitioning more of body energy for milk production. However, the objective of this study was mainly to study the effect of LCS under on- farm feeding condition. The dietary nutrient utilization and partitioning in diets warrants future investigation.

#### **Effect of L-carnitine supplemented diets on other performance parameters**

The result of this study on sows supplemented with L-carnitine during gestation had fewer SB piglets than those on C diet is in agreement with Musser *et al.* (1999); Eder *et al.* (2001) and Ramanau *et al.* (2002) who has shown that sows whose diet supplemented with L-carnitine during gestation had fewer numbers of SB piglets than those fed C diet. Since fewer SB piglets were farrowed from L-carnitine supplemented sows, more piglets born alive could be put through for rearing compared to those fed with C diet. The improved intrauterine fetal nutrition due to dietary L-carnitine could explain for fewer numbers of SB or non- viable piglets to LCS group (Eder, 2005). L-carnitine supplementation in sows during gestation reduces number of SB or non- viable piglets therefore provided more viable piglets to rear. But other factor such as number born alive should not be overlooked

Additionally, Waylan *et al.* (2005) found that L-carnitine fed during gestation would elicit a beneficial impact on fetal growth and development that can be observed with increased birth weights, reduced SB piglets, and increased muscle development. The present study indicated that no significant effect of NBA between sows fed diet supplemented with L-carnitine and those fed the C diet was found. It is possible that L-carnitine supplementation in sow gestation diet started 24 days after mating may not have influence on ovulation and conception rate. This

study also showed that PWS survival of litters was higher (95.66 %) in L-carnitine supplemented group than in C group (90.07 %). It would be possible that litters from L-carnitine supplemented group were heavier, healthier and vigorous at farrowing than in C group. Moreover, heavier litters would have higher suckling intensity, ingest more milk, grow faster and thrive well during pre-weaning period with higher litter survival rate (Auldust *et al.*, 1995; Eder, 2005). Hence, L-carnitine supplementation in sow gestation and lactation diets would positively improve dietary nutrient utilization and enhance their milk production in sows and would eventually wean large and heavier litters with higher PWS of litters and lesser SB piglets than that of control diet.

#### **Effect of L-carnitine supplemented diets on sow back fat thickness**

The current study showed that LCS diet during gestation has a significant effect on sows' BF thickness at farrowing compared to C diet. However, at weaning, no significant differences were found in sow BF thickness between LCS diet and the C diet. Likewise, no major changes and loss of BF thickness was observed from farrowing to weaning between diets. In this study, the sows in LCS group might have laid more adipose tissue during gestation and increase their back fat thickness at farrowing under the influence of L-carnitine than sows from C group. The results of present study concur with Musser *et al.* (1999) who has shown that sows supplemented with L-carnitine during gestation increased their weight and had higher BF thickness of last rib at farrowing compared to control sows. Moreover, the authors explained that sows supplemented with L-carnitine diet lay down more adipose tissue during pregnancy than sows on control diet. Hence, sow store more adipose tissue under the influence of additional L-carnitine during gestation.

In the present study, LCS diet could have impact on sows to lay more adipose tissue and

increased their back fat thickness at farrowing. Eder *et al.* (2001) found that L-carnitine supplementation in sows diet lead to higher live weight gain during pregnancy. In this study, the partitioning of energy for milk production in LCS sows seemed higher than in C sows. The greater BF thickness at farrowing and higher average daily feed intake during lactation by LCS sows could be the reasons for weaning heavier litters by LCS group than the C group. Woodworth *et al.* (2002) confirmed that both carnitine and chromium could exert on protein metabolism. The authors found that sow fed diet containing carnitine had lower plasma urea concentration suggesting less muscle catabolism than sows fed the C diet. It implied that carnitine would decrease the activity of branch- chained keto acid dehydrogenase, an important enzyme responsible for branch- chain amino acid catabolism. In the current study, LCS in sow diets could have a protein sparing effect such that the mobilization of protein might not have been increased. However, the sows must have utilized and partitioned more of dietary energy and adipose tissue for increased milk production and subsequently weaning heavier litters. Therefore, it is beneficial to supplement L-carnitine in gestation and lactation diets to get stable sow body condition and obtain heavier litters at weaning through increase milk production without going much into negative energy balance and its consequences.

#### **Effect of parity and barn on TLW**

From the present study, it was evident that parity has a significant effect on TLWw but it did not have any influence on TLW12 and TLW36 after farrowing. There was a linear increase in TLW with increasing parities from three to five. With advancing parities, i.e. from three to five, sows could become more mature and require less energy for growth and body maintenance. Alternatively, they could have partitioned more energy and put on weight into litter weight through

increased in milk production. The present result agrees with the finding of Yen *et al.* (1987) who reported that mid parity sows produced heavier litter weight and larger litter size than parity one and older than 6<sup>th</sup> parity sows. In addition milk yield increases with parity number and sow produce its maximum by 5<sup>th</sup> parity and then decline with increasing parities (Whittemore, 1998). In the present study, parity four and five sows could have partitioned more energy into milk production and weaned heavier litters compared to parity three sows.

### CONCLUSION

L-carnitine supplementation in sow gestation and lactation diets has increased TLW12 and TLW36 after farrowing and TLWw. L-carnitine supplemented diet did not influence on number of piglet born alive. However, fewer SB piglets were observed from diet supplemented with L-carnitine compared to C diet. The PWS of litters and LSw were found higher from LCS diet than the control. Moreover, sow BF thickness at farrowing was found higher in sows fed LCS diet as compared to those fed C diet. There was no significant difference in sow BF thickness at weaning and their changes from farrowing to weaning between sows fed LCS diet and those fed C diet. Therefore, L-carnitine supplementation in sow gestation and lactation diets has a beneficial effect on increasing TLW from farrowing to weaning, reducing number of SB piglets, increasing sow BF thickness at farrowing, increasing PWS of litters and LSw. Hence, it is recommended to supplement L-carnitine in sow gestation and lactation diets for optimizing sow and litter performance under commercial farm conditions.

### ACKNOWLEDGEMENT

The authors would like to express deep

appreciation and sincere thanks to Mr. Rawat Pokawattana, Trang Wattana Farm, in person for his permission to use farm animals, all logistic support to carry out field experiment and his management staff for their kind cooperation. Our sincere thank and great acknowledgement to Luechai Ippoodom, Thai Vet Nutri Tech Cooperation Limited for sponsoring L-carnitine. The author would like to sincerely express gratitude to Royal Government of Bhutan and Swiss Association for International Cooperation (SDC/Helvetas) in Bhutan for their financial supports.

### LITERATURE CITED

- Auldust, D. E., L. Morrish, C. Wakeford and R. H. King. 1995. Effect of Increased Suckling Frequency on Mammary Development and Milk Yield in Sows, pp 137. *In* D. P. Hennessy and P. D. Cranwell (eds.). **Manipulating Pig Production** Vol 137, Australian Pig Science Association, Werribee, Victoria, Australia.
- Cody, R. P. and J. K. Smith. 1997. **Applied Statistics and the SAS Programming Language**. New Jersey. 403 p.
- Coffey, M. T. B., G. Diggs, D. L. Handlin, D. A. Knabe, C. V. Maxwell, Jr., P. R. Noland, T. J. Prince and G. L. Gromwell. 1994. Effects of dietary energy during gestation and lactation on reproductive performance of sows: A cooperative study. **J. Anim. Sci.** 72: 4-9.
- DeRouchey, J., M. Tokach, S. Dritz, DVM, B. Goodb and J. Nelssen. 2005. Sow feed additives on the market: Are they worth it? Available source: [http:// www.kspork.org/producers/kstate](http://www.kspork.org/producers/kstate), Retrieved 7 March, 2006.
- Eder, K. 2005. Effects of L-carnitine supplementation in sows. **Chemical Monthly** 36 (6): 1535-1544.
- Eder, K., A. Ramanau and H. Kluge. 2001. Effect of L-carnitine supplementation on performance parameters in gilts and sows. **J.**

- Anim. Physiol.** 85: 73-80.
- Musser, R. E., R. D. Goodband, M. D. Tokach, K. Q. Owen, J. L. Nelssen, S. A. Blum, S. S. Dritz and C. A. Civis. 1999. Effects of L-carnitine fed during gestation and lactation on sow and litter performance. **J. Anim. Sci.** 77: 3289-3295.
- Ramanau, A., H. Kluge and K. Eder. 2005. Effect of L-carnitine supplementation on milk production, litter gain and back fat thickness in sows with a low energy and protein intake during lactation. **Br. J. Nutr.** 93: 717-721.
- Ramanau, A., H. Kluge, J. Spilke and K. Eder. 2002. Reproductive performance of sows supplemented with dietary L-carnitine over three reproductive cycles. **Arch. Anim. Nutr.** 56: 287-296.
- \_\_\_\_\_. 2004. Supplementation of sows with L-carnitine during pregnancy and lactation improves growth of the piglets during the suckling period through increased milk production. **J. Nutr.** 134: 86-92.
- Statistical Analysis System (SAS). 1999. **SAS User Guide**. SAS Institute Inc., Carry Carolina, USA. 584p.
- Waylan, A. T., J. P. Kayser, D. P. Gnad, J. J. Higgins, J. D. Starkey, E. K. Sissom, J. C. Woodworth and B. J. Johnson. 2005. Effects of L-carnitine on fetal growth and the IGF system in pigs. **J. Anim. Sci.** 83: 1824-1831.
- Whittemore, C. 1998. **The Science and Practice of Swine Production**. 2<sup>nd</sup> ed. Blackwell Science Ltd. Great Britain. 624 p.
- Woodworth, J. C., M. D. Tokach, J. L. Nelssen, R. D. Goodband, S. S. Dritz, S. I. Koo, J. E. Minton and K. Q. Owen. 2002. Influence of dietary carnitine/or chromium on blood parameters of gestating sows. pp 23-47. *In Swine Day 2002, Report of Progress 897*.
- Yen, H. F., G. A. Isler, W. R. Harvey and K. M. Irvin. 1987. Factors affecting reproductive performance in swine. **J. Anim. Sci.** 64: 1314-1348.