LYSINE AND METABOLIZABLE ENERGY REQUIREMENT FOR PROLIFIC LACTATING SOWS

Chung Wen Liao
Livestock Research Institute, Council of Agriculture
Nutrition Division, COA-LRI, Hsinhua, Tainan 712, Taiwan, R.O.C.
e-mail: chungwen@mail.tlri.gov.tw

ABSTRACT

During the last decade, with intense genetic selection and health improvement on breeding sows, the number of piglets born significantly increased. Appropriate feeds for lactating sows are critical in sow-herd management. Nutrient requirements for lactating sows comprise the need of maintenance and milk production. With high milk yield and low feed intake, sows will experience excessive body weight loss, resulting in the prolonged weaning to estrus interval. The needs of the high producing lactating sow for total lysine may exceed 60g·d^{-1}·sow^{-1}. Energy intake does have an effect on the body weight change and sows will mobilize their body reserve for milk production when energy balance becomes negative. Sows with reduced feed or energy intakes generally have lower milk yield. Factors influencing the energy requirement of lactating sow include genetics, parity, environmental condition, and body reserve at farrowing and lactation stages. Heat stress condition in local environment has negative effect on reproductive performance of sows and growth of piglets. Application of tunnel ventilation facility, provision of high nutrient density lactating diet, lower crude protein diet supplemented with lysine, can improve the reproductive efficiency of lactating sows when their energy intake is limited.

Keywords: Lysine, Metabolizable Energy, Lactating Sows, Reproductive Performance

INTRODUCTION

The total number of live pigs born has steadily increased since 2002 (Fig. 1). The improvement has been contributed to the genetic selection toward high prolificacy of sows. The contemporary sows have greater mature body size, high percentage of lean and less fat and have reduced appetite. The sows became more sensitive to nutritional manipulation and environmental conditions. Sows have larger litter size and litter growth rate. Thus, the high milk yield for large litter and fast growing piglets become a prime consideration.

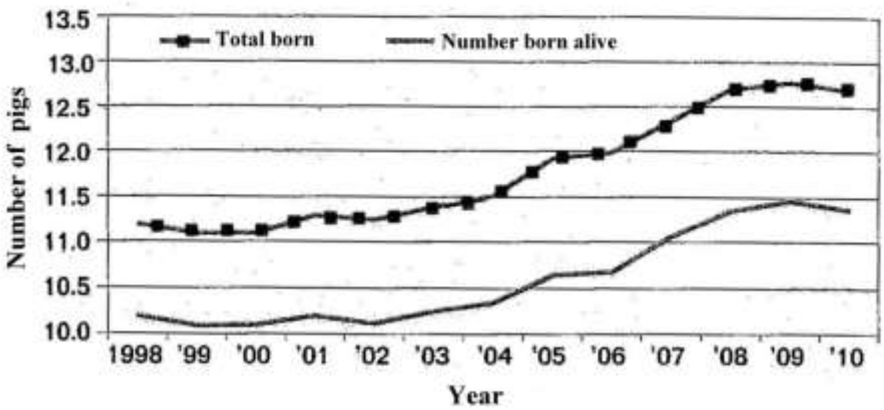

Fig. 1. The total number of pigs born and the number born alive for sows during last decade
Source: PigChamp Records Summary

Therefore, to understand the nutritional needs of modern sows during lactation are critical. The paper will emphasize on lysine and metabolizable energy needs for sows. Lysine, the first limiting amino acid in sow diet, has received renewed interest over the past decade for highly prolific sows and a wide range of optimum lysine and ME requirement are considered for lactating sows.

CRUDE PROTEIN OR LYSINE REQUIREMENT OF LACTATING SOWS

The optimal protein requirements for lactating sows have been well established under conventional climatic condition (Dourmad *et al*. 1994 and NRC 1998). Nevertheless, it has become a common practice to provide high amount of protein to the lactating sows for high prolificacy. Liao *et al*. (1999) compared the feeds with dietary CP 15%, 18%, 15% + 0.2% lysine for lactating sows to evaluate the effect of nitrogen provision on reproduction performance and growth of piglets. Results showed that there was no diet effect on body weight and backfat loss, interval between weaning to estrus for lactating sows (Table 1). The daily feed intake of sows were significantly depressed ($P<0.01$) by the hot climate which resulted in a greater ($P<0.01$) weight loss for sows. Litter weight gain was also lower ($P< 0.01$) during the hot season (Table 2). The result showed that a diet with CP 15% provides sufficient amino acid for the sows with medium litter size (8-9 piglets). Nevertheless, for that large litter size, Allee and Srichana (2008) indicated that increasing dietary lysine density resulted in linear increase in litter growth rate and increase in ADG of piglet (Fig. 2). No difference in ADFI, sow BW gain, weaning to estrus interval were observed (Table 3). Results also showed that providing 1.35% total lysine (1.20%, standardized ileal digestible, SID) for lactating gilts showed the highest litter production performance in the subsequent litter size. Young sows needed very high levels of lysine in lactation and that requirement for maximal prolificacy is greater than the requirement for milk production. At 70 g/d of total lysine intake derived from corn soybean meal diet, sows showed the highest litter growth rate at 2.52 kg/d. The sow's lysine requirement during lactation is influenced by dietary energy intake and litter growth rate. If energy in the lactation diet is limiting milk production, then addition of more protein will not necessarily increase milk yield (Tokach *et al.* 1992). If the energy is adequate, then it is the milk yield's response to dietary protein intake and these results in increased weaning weight of piglets (Fig. 3). Increasing energy content of lactation feed will not increase the feed (energy) levels to sows need. This is because the elevating energy content of the feed will require added fat, and the amount will exceed 5-6%. This might influence the feed intake. Instead, there is a need to focus on amino acid requirement. By calculation, each 1% increase in dietary protein content can result in a 0.11 kg increase in piglet body weight at weaning. Recently, a standardized ideal digestible lysine, or SID lysine is used. Formulating on a digestible amino acid basis has become especially important with the increased use of feed alternative or crystalline amino acids in lactation diet. Recent research for high-producing sows suggests that a SID lysine requirement of 55 to 65 g/d/sow to maximize litter weaning weights and reduce sow weight loss. That is equal to a 1.1% lactation feed intake of 5-6 kg/d.

Table 1. Main effects of dietary protein regimens, and climate on reproductive criteria for lactating sows

Item	Dietary protein regimens			Climate*			Significance	
	15% crude protein	18% crude protein	15% crude protein added lysine	Cool	Hot	SEM	Protein	Climate
Weight postfarrowing, kg	184.6	177.9	192.0	182.6	186.9	5.0	NS	NS
Weight of sow at weaning, kg	166.9	166.9	176.0	173.3	166.6	4.9	NS	NS
Weight loss during lactation, kg	17.7	10.9	16.0	9.3	20.4	2.1	NS	0.01
Backfat loss during lactation, mm	1.5	1.3	2.1	1.4	1.9	0.6	NS	NS
Average feed intake, kg/d	3.98	3.72	3.86	4.61	3.09	0.18	NS	0.01
Interval from weaning to estrus, d	6.4	6.5	6.5	5.7	7.2	0.8	NS	NS

$P < 0.05$, significantly different; $P < 0.01$, highly significantly different.
* The low temperature from May to October was 18.4-23.5℃; The high temperature from May to October was 33.9-37.2℃.
The low temperature from November to April was 9.7-16.9℃; The high temperature from November to April was 30.4-34.4℃.
(Liao et al. 1999)

Table 2. Main effects of dietary protein regimens and climate on the growth and survival rate of piglets

Item	Dietary protein regimens			Climate			Significance	
	15% crude protein	18% crude protein	15% crude protein added lysine	Cool	Hot	SEM	Protein	Climate
Sow farrowing	34	32	32	45	53			
Live piglets at farrowing	8.74	8.36	8.66	8.62	8.55	0.40	NS	NS
Litter size at weaning	7.57	7.46	7.32	7.68	7.22	0.40	NS	NS
Survival rate during lactation	87.6	87.8	84.4	89.7	83.6	2.70	NS	0.06
Piglet weight at farrowing, kg	1.30	1.25	1.36	1.32	1.28	0.04	NS	NS
Piglet weight at 4 wks of age, kg	6.61	6.47	7.04	7.54	5.86	0.24	NS	0.01
Piglet weight gain during lactation, kg	5.31	5.22	5.68	6.22	4.58	0.23	NS	0.01

$P < 0.05$, significantly different; $P < 0.01$, highly significantly different. (Liao et al. 1999)

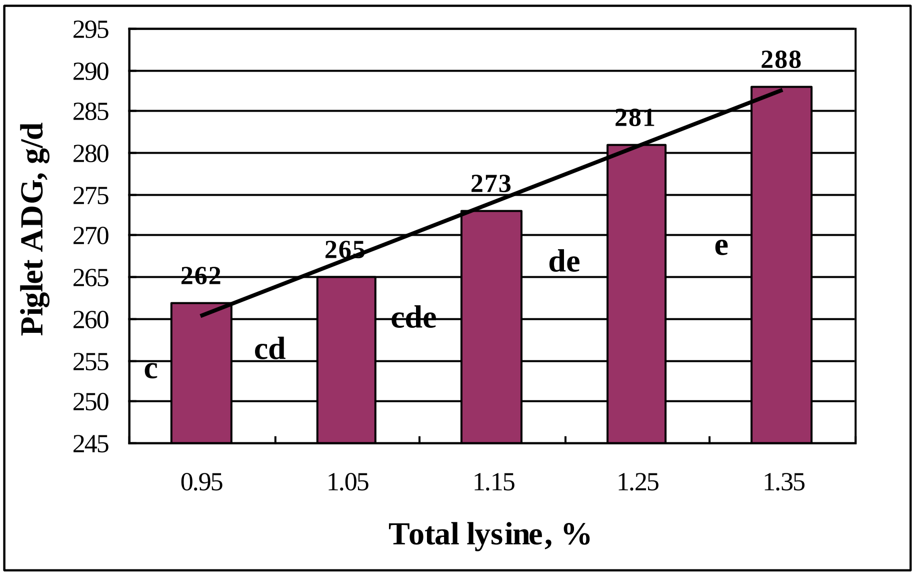

Fig. 2. Effect of dietary lysine intake on piglet ADG (g/d). (Allee and Srichana 2008)

Table 3. Effect of Dietary Lysine on Sow and Litter Performance

	Lysine, %				
	0.95	1.05	1.15	1.25	1.35
Sow BW change, kg	4.4	5.1	4.2	4.7	5.5
Weaned to estrus, d	7.5	7.7	7.1	9.2	6.2
% breed back within 10d Subsequent reproductive performance	88.9	90.1	90.1	82.0	96.3
Total born, pig	12.9	12.8	12.4	11.9	12.3
Born alive, pig	11.6	11.8	11.7	11.2	11.5
Still born, pig	0.8	0.6	0.6	0.5	0.6
Mummies, pig	0.2	0.2	0.2	0.2	0.2

(Allee and Srichana 2008)

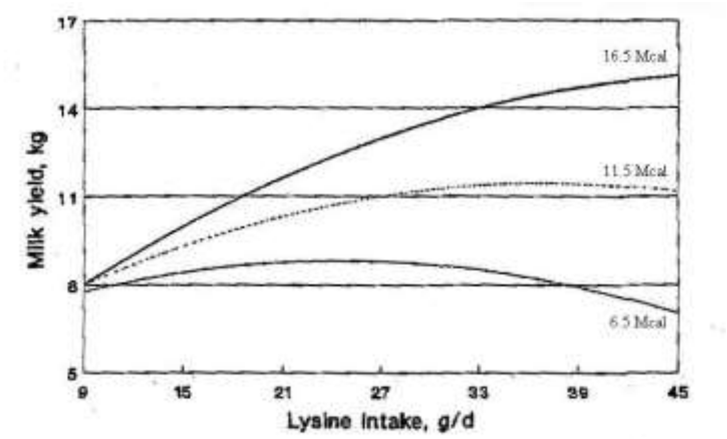

Fig. 3. Predicted influence of lysing and ME (Mcal) intakes on milk yield on d 22. Curves derived from the following prediction equation (R^2=0.74): milk yield = 803.6 + (73.67) lysine - (64.69) ME - (4.37) lysine^2 - (4.63) ME^2 + (21.74) (lysine × ME). Average prediction error 1.5 kg. (Tokach *et al.* 1992)

SOWS NEED FULL FED DURING LACTATION

It was well known that high prolific lactating sows need maximum intake of a good quality diet to optimize sow and litter performance. However, the feed intake for many lactating sows is limited due to high lean body composition, environmental factors, etc. Low feed intake in lactation resulted in decreased milk production and excessive loss of sow weight and body fat, which can impair subsequent reproductive performance. The goals of the nutrition management for lactating sows are to maximize intake of a well formulated diet during lactation to maintain body composition and ensure a successful postweaning estrus for sows.

Achieving sufficient feed intake starts with proper body condition when the sows come to the farrowing barn. If the sows are too fat, they will eat less in lactation (Fig. 4). This will cause excessive weight loss and will have poor subsequent reproductive performance. Because sows did not eat as much in lactation, they lost more body fat as a percentage of body weight. This results in a smaller litter size in subsequent farrowing (Fig. 5). It is inevitable that the modern hyperprolific sow will lose body weight and body condition during lactation and a loss of 10-15 kg body weight is acceptable (Close and Cole 2000). Hughes (1989) reported that primiparous sows fed with high level of dietary energy had a weaning to remating interval of 12.7 d, whereas those receiving a low energy intake had a weaning to remating interval of 19.3 d. For older sows, the effect of energy intake was smaller. Thus, the under-provision of energy during lactation increases the weaning to remating interval in gilts, but not in mature sows. Older sows have a higher feed intake and the demands for growth in the maternal body are less compared with the primiparous sow. Primiparous sows, poorly fed during lactation, those that had larger litters or animals which lost considerable body weight and condition, may benefit from a high energy intake after weaning. In conclusion, sows need to be fed fully as quickly as possible after farrowing.

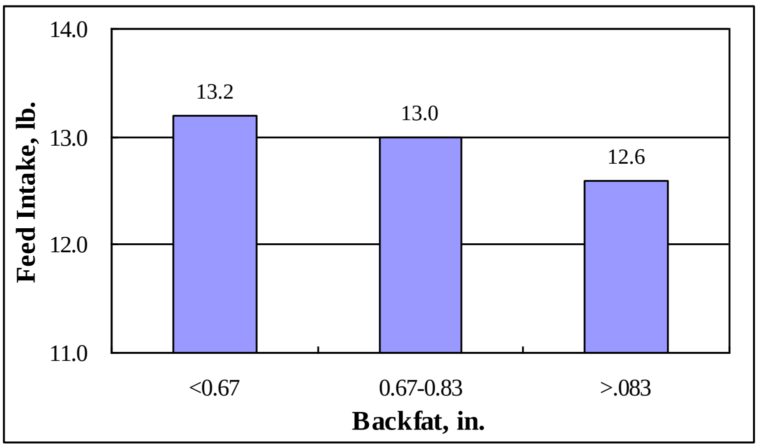

Fig. 4. Influence of backfat at farrowing on lactation feed intake. (Young *et al.* 2003)

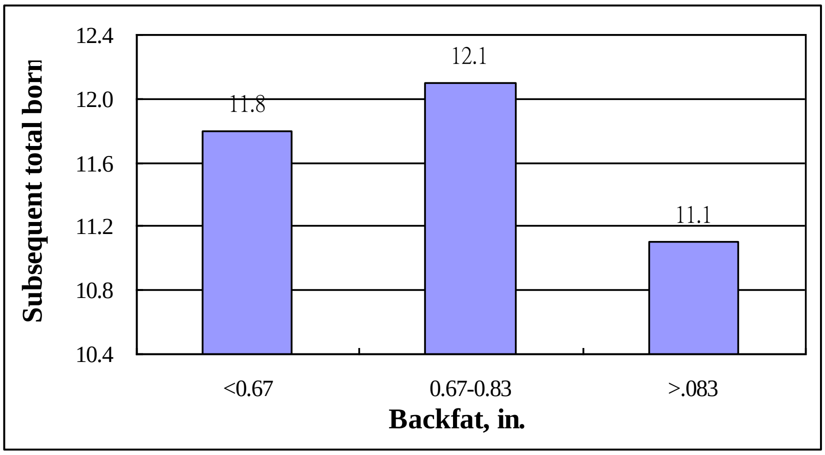

Fig. 5. Influence of backfat at farrowing on subsequent total born. (Young *et al.* 2003)

EFFECT OF METABOLIZABLE ENERGY INTAKE ON REPRODUCTIVE PERFORMANCE OF SOWS

Due to limited feed intake for lactating sows, they will lose body weight and fat mass. Excessive mobilization of body reserve will cause the postweaning infertility. Liao and Hsu (1987) in their early experiment showed that the interval between weaning and estrus was prolonged for those sows daily provided with 10.3 or 11.3 Mcal ME /d /sow when compared with fed 12.3 Mcal ME/d. The body weight gain of piglets nursed by sows with lower energy intake were also suppressed (Table 4). This amount of 12.3 Mcal ME/d is equivalent to the daily provision of 4 kg of lactation diet when sow nurse eight piglets. Another experiment was conducted in environmental chambers to validate the environmental temperature effect on reproductive performance of sows (Liao *et al.* 2010). Sows were raised under three different ambient temperatures with constant 20℃, 25℃, 30℃. Feed intake of sows was reduced when they were raised in 30℃ compared to 20℃ (Table 5). There was no difference on nitrogen and energy digestibilities of diets for sows under different ambient temperatures. The backfat thickness reduction for sows was numerically increased at 30℃, compared to those of lower temperatures. No difference was found in growth and survival rate of piglets among temperatures group (Table 6). In conclusion, the 30℃ ambient temperature on this experiment was a heat stress for lactating sows and sows had to mobilize the body tissue to provide the nutrients required for the growth of piglets.

Table 4. Effect of the metabolizable energy intake for sows on lactating performance and growth of piglet

	ME intake, Mcal ME/d		
Criteria	10.3	11.3	12.3
Body weight loss of sows, kg (0-28 d lactation)	27.3	24.6	21.7
Backfat thickness loss of sows ,mm	4.1	4.2	3.1
Weight gain of piglets (0-28 d)	4.7[a]	5.1[a]	5.1[b]
Sows return to estrus within 7 days postweaning, %	54[a]	54[a]	84[b]

[a,b] Means within the same row without common superscripts differ significantly (P < 0.05).

(Liao and Hsu1987)

Table 5. Effects of ambient temperatures on the feed intake, body compositions and reproductive performance of lactating sows

Items	Ambient temperatures, ℃			SEM
	20	25	30	
Number of sows	6	6	6	
Body weight at farrowing, kg	237.0	228.1	236.4	10.37
Body weight at weaning, kg	217.2	208.1	206.7	12.24
Body weight loss during lactation, kg	19.8	20.0	29.7	5.6
Backfat thickness reduction during lactation, mm	1.2	1.6	2.8	0.88
Feed intake during d 8 to d 28 of lactation, kg/d	5.36[a]	4.54[a]	2.61[b]	0.41
Interval from weaning to estrus, d	5.24 (4)[*]	4.75 (4)	5.20 (5)	5.50

[a,b] Means within the same row without common superscripts differ significantly (P < 0.05).

[*] The number in parentheses represents the number of sows measured.

(Liao *et al.* 2010)

Table 6. Effects of ambient temperatures on the growth and survival rate of nursing piglets[*]

Items	Ambient temperatures, ℃			SEM
	20	25	30	
Number of sows	6	6	6	
Live piglet at birth	11.5	10.17	9.67	0.83
Litter size at weaning	11.33	10.00	9.67	0.87
Body weight of piglet at birth, kg	1.39	1.62	1.52	0.07
Body weight of piglet at weaning, kg	7.07	7.52	7.04	0.42
Weight gain of piglet during lactation, kg	5.68	5.91	5.52	0.40
Survival rate of piglet, %	98.61	97.62	100	1.59

[*] No differences among treatments.

(Liao *et al.* 2010)

ALLEVIATION OF HEAT STRESS EFFECT ON REPRODUCTIVE PERFORMANCE OF SOWS BY NUTRITIONAL MANAGEMENT AND FACILITY

As indicated above, the heat stress effect will cause the reduction of feed intake for lactating sows. Liao *et al.* (2006) evaluated the effect of applying water pad cooling barn for lactating sows during the hot summer (From June to September) in Taiwan. The result showed that there was a shorter interval from weaning to estrus for sows raised in water pad cooling barn (Table 7 and Table 8) and the lactational weight gain for piglets raised by sows under water pad cooling barn was larger (P<0.05) than those in conventional open air barn.

Table 7. The effect of sows raised in either conventional open air barn or water pad cooling barn on

the reproduction efficiency of sows

Items	COAB	WPCB	SEM
Number of sows	18	12	
Body weight at farrowing, kg	201.6	209.9	6.10
Body weight at weaning, kg	187.5	196.9	6.30
Body weight loss during lactation, kg	14.1	13.0	2.40
Backfat loss during lactation, mm	2.2	2.5	0.50
Feed intake during lactation, kg/d	3.56	3.71	0.18
Interval from weaning to estrus, d	15.3	7.2	4.80

COAB: conventional open air barn; WPCB: water pad cooling barn

[*] Experiment was conducted from June to September at Southern subtropic Taiwan.

(Liao *et al.* 2006)

Table 8. The effect of sows raised in either conventional open air barn or water-pad cooling barn on the growth and survival rate of nursing piglets

Items	COAB	WPCB	SEM
Number of sows	18	12	
Litter size at birth	12.10	10.50	0.70
Live piglets at birth	10.10	9.50	0.60
Litter size at weaning	9.20	9.00	0.50
Body weight of piglet at birth, kg	1.40	1.56	0.05
Body weight of piglet at weaning, kg	6.15[a]	7.75[b]	0.28
Weight gain during lactation, kg	4.75[c]	6.20[d]	0.28
Survival rate of piglet, %	92.50	94.9	2.20

[a, b] Means within the same row without common superscripts differ significantly ($P < 0.001$).

[c, d] Means within the same row without common superscripts differ significantly ($P < 0.01$).

(Liao *et al.* 2006)

The low feed intake for primiparous sows and the high lean percentage in body composition contribute to the excessive body weight loss during lactation. This often results in the thin sow syndrome, esp. in the hot season. Therefore, Liao *et al*. (2002) conducted the experiment to evaluate the feasibility of increasing nutrient density of lactating diet. The diet for control was formulated on the feeding standard of Pigs (Taiwan) and (HND) represents the high nutrient density diet which nutrients were 10% higher than the control group. The result showed that the feed intake for lactating sows either in the control group or nutrient elevated group were seriously restricted under hot temperature. There was no difference on the interval between weaning and estrus of sows between the two groups. The body weight gain of piglets during lactation for sows fed with high nutrient density diet was larger ($P<0.05$) than those piglets in the control group, indicating that the sows fed with high nutrients density diet will provide nutrients for piglets even if the feed intake was severely inhibited during the hot summer months in Taiwan (Table 9 and Table 10).

Table 9. Effect of feeding high nutrient density diet on lactation body weights and backfat loss of primiparous sows.

Items	Nutrient density*		SEM
	Control	HND	
Number of sows	12	12	
Weight of sow, kg			
At postfarrowing	198.80	192.40	8.00
At postwening	166.50	166.10	7.60
Weigh loss during lactation	32.30	26.30	4.00
Backfat loss during lactation	1.70	1.10	1.40
Feed intake, kg/d	3.16	3.24	0.20
Interval between weaning and estrus, day	10.80	7.90	2.70

* The control diet was formulated on the feeding standard of Pig in Taiwan and HND represents the high nutrient density diet which nutrients is 10% higher than the control diet.

(Liao *et al.* 2002)

Table 10. Effect of feeding high nutrient density diet to primiparous sows on the growth and survival rate of piglets

Item	Nutrient density*		SEM
	Control	HND	
Daily nutrient intake			
Feed intake, kg/d	3.16	3.24	0.20
Crude protein, g/d	47.4	53.5	3.2
Metabolizable energy, Mcal/d	10.1[a]	11.3[b]	0.07
Lysine, g/d	24[a]	28[b]	1.6
Litter size, number			
Live piglet at farrowing	9.50	10.3	0.70
Live piglets at weaning	8.60	8.9	0.8
Survival rate, %	90.5	86.4	5.5
Weight of piglet, kg			
At farrowing	1.39	1.38	0.04
At 28-day of age	6.87[a]	7.36[b]	0.23
Weight gain during lactation	5.49[a]	5.98[b]	0.24
Litter weight, kg			
At farrowing	13.2	14.2	1.2
At weaning	59.1	65.5	3.3
Litter weight gain during lactation	45.9	51.3	3.1

* As in Table 9.

[a,b]: Means on the same row with different superscripts differ significantly($P<0.05$).

(Liao *et al.* 2002)

Liao *et al*. (1998) evaluated the effect of dietary supplementing chromium picolinate on the reproductive performance of sows and their piglets. Chromium is a cofactor of insulin and regarded as a glucose tolerance factor. It can enhance the insulin efficacy. Insulin plays a critical role in nutrient utilization and deposition process. Thus, in the case of a sow which suffered from the negative nutrient balance, the supplementation of chromium might be an aid to the restoration of its lost body composition. In this experiment, 200 ppb or 400 ppb chromium (Chromium picolinate) were added in sow diet for evaluating its effect on reproductive performance of sows and growth of piglets. Results showed that the supplementation of 400 ppb chromium increased ($P<0.05$) the gestation body weight gain of primiparous sows and reduced ($P<0.05$) the interval between weaning and service of sows when 200 ppb chromium was supplemented (Table 11 and Table 12).

Table 11. Effect of chromium picolinate supplementation on reproductive performance of first parity sows

Items	Cr, ppb			SEM
	0	200	400	
Number of sows	18	18	18	
Body weight at farrowing, kg	173.20	187.50	184.70	4.2
Body weight at weaning, kg	158.10	164.20	160.80	4.8
Weight loss during lactation, kg	15.10	23.20	23.90	4.7
Feed intake, kg/d	3.07	3.04	3.19	0.2
Backfat thickness reduction in lactation, mm	2.69	2.60	2.71	0.5
Interval between weaning and service, d	23.50	15.60	18.10	6.1

[a, b]: Data in the same row with different superscript differ significantly (P < 0.05).

(Liao *et al.* 1998)

Table 12. Effect of chromium picolinate supplementation on reproductive performance of 1-3 parity sows

Items	Cr, ppb			SEM
	0	200	400	
Number of sows	18	17	17	
Body weight at farrowing, kg	201.05	204.20	214.60	3.40
Body weight at weaning, kg	176.40	179.40	179.80	4.30
Weight loss during lactation, kg	24.90	24.90	34.20	6.00
Feed intake, kg/d	3.69	3.88	3.67	0.16
Backfat thickness reduction in lactation, mm	3.20	3.10	3.64	0.50
Interval between weaning and service, day	17.60[a]	7.50[b]	9.80[ab]	4.70

[a, b]: Data in the same row with different superscript differ significantly (P < 0.05).

(Liao *et al.* 1998)

CONCLUSION

The effort to increase litter size and weights for sows has been successful over the past decade. The feed intake capacity during lactation to support the nursing ability and postweaning reproduction remains a limiting factor. Sows need to be fully fed at the post farrowing stage in order to obtain maximal milk yield. The lysine requirement for lactating sows should be increased when considering the high milk yield and subsequent reproductive performance. Sows experiencing excessive body weight or fat loss have to provide amount of higher nutrients density diet. During hot climate, application of water pad cooling barn for lactating sows increased the weight gain of piglets. The supplementation of 400 ppb chromium increased the gestational body weight gain of primiparous sows and reduced (P<0.05) the interval between weaning and service of multiparous sows when 200 ppb chromium was supplemented.

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