# Effect of Dietary Protein and Lysine Levels on Lactating Multiparous Sows and Litter Performance

C. S. Cheng[1]*, H. T. Yen, S. W. Roan[1], J. F. Wu and J. C. Hsu[1]
Department of Production Management, Pig Research Institute Taiwan, P. O. Box 23, Chunan, 35099 Miaoli, Taiwan, ROC

**ABSTRACT** : The effects of dietary protein and lysine levels on lactating multiparous sows and litter performance were studied. Sixty-two crossbred multiparous sows (Landrace×Yorkshire) were used. Thirty-three and twenty-nine sows were studied in their second parity and third parity respectively. The three dietary treatments were: (1) the control diet containing 15% CP and 0.75% lysine, (2) a diet containing 13% CP and 0.75% lysine (0.60% natural+0.15% synthetic), and (3) a diet containing 13% CP and 0.60% lysine. They were fed twice daily and allowed *ad libitum* access to food and water throughout a 28 day lactation from parturition until weaning. The results of this experiment showed that body weight and backfat losses of the sows from farrowing to weaning were significantly affected ($p<0.01$) by reducing dietary protein. Neither average daily feed intake nor weaning to estrus interval of sows were significantly different among treatments. Supplementing lower dietary protein with synthetic lysine could mitigate backfat losses, but could not prevent body weight losses in lactating multiparous sows. A corn-soybean meal diet containing 13% crude protein and 0.60% lysine did not significantly affect litter size and survival rate of weanling piglets compared with the 15% crude protein diet. There was a tendency towards decreased piglet weight at weaning ($p<0.10$) and reduced daily gain of piglets ($p<0.11$) when the multiparous sows were fed the 13% protein diet during lactation. We found a severe loss of body weight and backfat when reducing dietary protein for lactating multiparous sows. (*Asian-Aust. J. Anim. Sci. 2001. Vol. 14, No. 1 : 77-81*)

**Key Words** : Protein, Lysine, Sow, Piglet, Performance

## INTRODUCTION

Lysine is considered to be the first limiting amino acid in typical corn-soybean meal lactation diets. Chen et al. (1978) reported that the average litter weight gain and milk yield increased linearly with increasing dietary levels of lysine from 0.39 up to 0.79% when sows received a diet containing 10% crude protein in their second parity. Chen et al. (1990) showed that the net gain per litter was significantly increased by increasing the essential amino acid content (lysine, methionine+cystine, threonine, tryptophan, and valine) up to 30% in lactation diets. In the search for greater efficiency in animal production, together with a minimum of excretory products, greater precision in non-ruminant diets will result from better knowledge of the requirements for essential amino acids, together with their commercial availability in a crystalline form (Cole, 1991; Han and Lee, 2000). Taylor et al. (1979) showed that the need for total crude protein was reduced from 17.6 to 14.5% solely by the addition of synthetic lysine. The consequences were an improved balance of essential amino acids in relation to the ideal protein (Cole, 1978; Baker, 2000), the same performance by the pigs, and less nitrogen excreted (Han and Lee, 2000). The lactating sow requires a greater daily lysine intake to optimize its nitrogen balance than to maximize lactational performance (King et al., 1993). A restricted intake of amino acids and excessive mobilization of body protein (i.e., negative nitrogen balance) during lactation have been associated with the occurrence of postweaning anestrus in sows (King and Dunkin, 1986; Brendemuhl et al., 1987; King and Martin, 1989; Jones and Stahly, 1995). Noblet and Etienne (1987) recorded a decrease in muscle weight in a gilt of about 10 kg over a 21 d lactation and a negative nitrogen balance, suggesting that its supply of protein was not adequate. Recent studies have indicated that modern sows require much higher amino acid supplies, mainly because of their increased milk production and larger litters (Stahly et al., 1990; Johnston et al., 1993; King et al., 1993; NRC, 1998). Insufficient protein or amino acid supplies can decrease milk production (King and Dunkin, 1986; Eastham et al., 1988; King et al., 1993) and affect subsequent reproductive performance (King and Williams, 1984). King (1987) suggested that loss of body protein could have a greater effect on return to estrus after weaning that loss of body fat. The objective of this experiment was to evaluate the effects of a low protein diet supplemented with synthetic lysine on reproductive and litter performance of sows.

* Address reprint request to C. S. Cheng. Tel: +886-37-672352 (ext. 308), Fax: +886-37-660104, E-mail: cscheng@mail.prit.org.tw.
[1] Department of Animal Science, National Chung-Hsing University, 250 Kao-Kung Road, Taichung, 402, Taiwan, ROC.
Received April 22, 2000; Accepted September 15, 2000

## MATERIALS AND METHODS

### Experimental animals and dietary treatments

Sixty-two crossbred multiparous sows (Landrace×Yorkshire) were used in this experiment. Thirty-three and twenty-nine sows were studied in their second parity and third parity, respectively. During gestation, the sows were daily fed 2 kg of a diet based on corn-soybean meal-wheat bran containing 13% crude protein (CP), 0.60% lysine, and 3.36 Mcal/kg digestible energy (table 1). After farrowing, the sows were randomly and equally allocated to one of three dietary treatments. The three treatments were: (1) the control diet containing 15% CP and 0.75% lysine, (2) a diet containing 13% CP and 0.75% lysine (0.60% natural+0.15% synthetic), and (3) a diet containing 13% CP and 0.60% lysine. The composition and chemical analyses of the diets are given in table 1. The digestible energy contents of three diets were formulated to equal that of the gestation diet. Vitamin and mineral contents were similar in the three diets.

### Management of sows and piglets

Sows began receiving the experimental diets at farrowing. They were fed twice daily and allowed *ad libitum* access to diet and water throughout a 28-day lactation from parturition until weaning. Feed intake was recorded for the entire lactation. The sows were weighed and their backfat depth was measured using an ultrasound device (Scanoprobe 731C, Ithaco Co., USA) within 24 h after farrowing and at weaning. The averages of the backfat thickness at approximately 65 mm off the midline over the first rib, last rib, and last lumbar vertebrae were measured. Piglets were individually weighed at birth, and then weekly during lactation, and at weaning. Piglets were treated by routine management practices that included needle teeth clipping, ear notching, and iron injections (200 mg/pig) within 1 d of parturition. After weaning, the sows were moved into gestation stalls and monitored for estrus daily, using a boar, from weaning until estrus was detected. The number of days from weaning to estrus was recorded.

### Analytical methods

A sample of the lactation diet was collected from each batch at mixing or once a month. Pooled samples were subjected to analysis for nitrogen, ether extract, crude fiber, calcium, and phosphorus by the methods of the Association of Official Analytical Chemists (1984). Gross energy was determined using an adiabatic oxygen bomb calorimeter (Parr Instrument Co., Moline, Illinois). Lysine was analyzed by ion-exchange chromatography (Biotronik, Amino Acid Analyzer, LC 5001, Wissenschaftliche Gerate Gmbh).

The data were analyzed by ANOVA as a completely randomized design. The independent variables in the statistical model were the main effects of the lactation dietary treatment. Mean squares based on type III sums of squares were tested using the residual error term. Individual sows and litter measurements were considered as the experimental units. All data showing any effect of diet on litter growth rate or sow performance between treatments were evaluated. All statistical analyses were computed using the GLM procedure of SAS (1988). Differences between treatment means were tested by Duncan's

**Table 1.** Composition of diets for lactating sows

| Item | Treatment | | |
|---|---|---|---|
| | 1 | 2 | 3[c] |
| Ingredients, % | | | |
| Ground corn | 72.80 | 78.82 | 78.50 |
| Soybean meal | 18.64 | 12.34 | 12.88 |
| Wheat bran | 6.0 | 6.0 | 6.0 |
| Dicalcium phosphate | 1.42 | 1.55 | 1.54 |
| Limestone, pulverized | 0.54 | 0.47 | 0.48 |
| Salt | 0.4 | 0.4 | 0.4 |
| Vitamin premix[a] | 0.1 | 0.1 | 0.1 |
| Mineral premix[b] | 0.1 | 0.1 | 0.1 |
| Lysine-HCl (78% lysine) | - | 0.22 | - |
| Nutrient composition (calculated value, %) | | | |
| Crude protein (N×6.25) | 15.00 | 13.00 | 13.00 |
| Crude fat | 3.06 | 3.21 | 3.21 |
| Crude fiber | 3.63 | 3.31 | 3.34 |
| Calcium | 0.80 | 0.80 | 0.80 |
| Phosphorus | 0.65 | 0.65 | 0.65 |
| Lysine | 0.75 | 0.75 | 0.60 |
| Methionine | 0.24 | 0.22 | 0.22 |
| Methionine+cystine | 0.54 | 0.49 | 0.49 |
| Threonine | 0.60 | 0.51 | 0.52 |
| Isoleucine | 0.66 | 0.56 | 0.56 |
| Valine | 0.77 | 0.66 | 0.67 |
| Digestible energy, Mcal/kg | 3.36 | 3.36 | 3.36 |
| Nutrient content (%) as analyzed | | | |
| Crude protein (N×6.25) | 14.63 | 12.57 | 12.59 |
| Crude fat | 2.79 | 2.67 | 2.73 |
| Crude fiber | 3.26 | 2.93 | 2.99 |
| Calcium | 0.88 | 0.86 | 0.85 |
| Phosphorus | 0.66 | 0.63 | 0.64 |
| Lysine | 0.73 | 0.74 | 0.59 |

[a] Supplied per kg of diet: vitamin A, 4,000 IU; vitamin $D_3$, 600 IU; vitamin E, 22 IU; menadione, 2.0 mg; thiamin, 1.0 mg; riboflavin, 4.0 mg; vitamin $B_6$, 1.0 mg; vitamin $B_{12}$, 0.02 mg; niacin, 40 mg; pantothenic acid, 12 mg; folic acid, 0.4 mg; biotin, 0.2 mg; choline chloride, 1.0 g.

[b] Supplied per kg of diet: Zn, 80 mg; Cu, 6 mg; Fe, 80 mg; Mn, 10 mg; I, 0.2 mg; Se, 0.1 mg.

[c] The composition of the gestation diet.

New Multiple Range Test (Duncan, 1955).

## RESULTS AND DISCUSSION

The effects of dietary protein and lysine levels on the lactating multiparous sows are shown in table 2.

The average daily feed intakes and weaning to estrus intervals were not significantly different 1, 2 and 3 among treatments 1, 2 and 3. The average daily feed intake of sows was 5.54, 4.80, and 4.96 kg, respectively, during the 28-day lactation period; weaning to estrus interval of sows was 7.7, 10.5, and 10.1 days, respectively. The sows' body weight and backfat thickness at farrowing and weaning were not affected by the dietary treatments. Sow body weight at farrowing and weaning were 200.38, 187.98; 193.16, 172.06; and 202.05, 177.67 kg, respectively, for the three treatments. Dourmad et al. (1998) and Knabe et al. (1996) reported that a sow's feed intake was not affected by diet. Touchette et al. (1998b) and Yen and Cheng (1995) also found that feed intake, body weight, and backfat thickness at farrowing and weaning, and weaning to estrus interval of sows were not affected by the level of dietary protein. Similarly, Stahly et al. (1990), Johnston et al. (1993), Monegue et al. (1993), Weeden et al. (1994), Knabe et al. (1996), and Touchette et al. (1998a) reported that dietary protein and lysine levels did not affect weaning to estrus interval.

Body weights and backfat losses of sows from farrowing to weaning were significantly affected ($p<0.01$) by reduction of dietary protein (table 2). Body weight losses were 12.40, 21.10, and 24.38 kg, and backfat losses were 0.06, 0.16, and 0.32 cm for treatments 1, 2, 3 respectively during the lactation period. No matter whether the lysine content was 0.75% or 0.60% in the lactating diets, the losses of body weight were higher in sows on the 13% dietary protein during lactation. However, at the dietary lysine level of 0.75%, the sows fed the lower protein (13%) diet supplemented with synthetic lysine showed backfat losses not significantly different from those on the higher protein (15%) diet during lactation. Average daily feed intake was not significantly different among the dietary treatments, the daily protein and lysine intake of sows were low for those on the 13% protein treatment. Therefore, it would appear that it was the low protein and lysine intake that resulted in body weight losses during lactation. Similarly, Stahly et al. (1990), Johnston et al. (1993), Richert et al. (1997), and Touchette et al. (1998b) reported that, when the dietary lysine level was reduced, the loss of body weight during the lactation period increased. Monegue et al. (1993) and Richert et al. (1997) reported that increasing the protein content in the lactating diet reduced sows' loss of body weight during lactation. Brendemuhl et al. (1989) and King (1987) also implicated a reduced dietary protein intake during lactation to be responsible for the loss of large amounts of backfat and body protein. The results of our experiment showed that reducing dietary protein increased the loss of body weight and backfat by lactating multiparous sows. Supplementing a lower dietary protein with synthetic lysine could mitigate the backfat losses, but could not prevent the losses of body weight by such sows.

The effects of the dietary protein and lysine levels provided to the lactating multiparous sows on the performance of nursing piglets are shown in table 3.

The litter size at initial and at weaning stages and survival rate of weaned piglets were not significantly different among the three treatments. Litter sizes of piglets at initial and weaning stages were 9.5, 9.25; 10.05, 9.67; and 9.88, 9.53, respectively, for

**Table 2.** Efect of dietary protein and lysine levels on the performance of lactating multiparous sows

| Protein, %<br>Lysine, % | 15<br>0.75 | 13<br>0.75 | 13<br>0.60 | SEM | Significance |
|---|---|---|---|---|---|
| No. of sows | 24 | 21 | 17 | | |
| Daily feed intake, kg | 5.54 | 4.80 | 4.96 | 0.17 | 0.15 |
| Sow body weight, kg | | | | | |
| At farrowing | 200.38 | 193.16 | 202.05 | 3.27 | 0.51 |
| At weaning | 187.98 | 172.06 | 177.67 | 3.53 | 0.15 |
| Loss | -12.40[a] | -21.10[b] | -24.38[b] | 1.52 | 0.005 |
| Sow backfat thickness, cm | | | | | |
| At farrowing | 2.15 | 2.10 | 2.27 | 0.07 | 0.57 |
| At weaning | 2.09 | 1.94 | 1.96 | 0.06 | 0.52 |
| Loss | -0.06[a] | -0.16[a] | -0.32[b] | 0.03 | 0.002 |
| Weaning to estrus interval[1], day | 7.7 | 10.5 | 10.1 | 1.28 | 0.62 |

[1] Number of sows was 22, 20 and 14 for the three treatments.

[a,b] Means within the same row without the same superscript letters are significantly different ($p<0.05$).

**Table 3.** Effect of dietary protein and lysine levels for lactating multiparous sows on the performance of nursing piglets

| Protein, %<br>Lysine, % | 15<br>0.75 | 13<br>0.75 | 13<br>0.60 | SEM | Significance |
|---|---|---|---|---|---|
| Litter size | | | | | |
| Initial | 9.50 | 10.05 | 9.88 | 0.18 | 0.42 |
| Weanling | 9.25 | 9.67 | 9.53 | 0.19 | 0.64 |
| Survival, % | 97.51 | 95.79 | 96.59 | 0.73 | 0.60 |
| Piglet weight, kg | | | | | |
| Initial | 1.54 | 1.45 | 1.53 | 0.03 | 0.32 |
| Weanling | 7.07 | 6.43 | 6.48 | 0.14 | 0.10 |
| Daily gain | 0.198 | 0.179 | 0.178 | 0.004 | 0.11 |
| Litter weight gain, kg | 51.13 | 47.95 | 47.08 | 1.26 | 0.37 |

treatments 1, 2 and 3. The percentage piglet survival rates at weaning were 97.51, 95.79, and 96.59%, among which no statistical differences were found. Yen and Cheng (1995) and Cheng et al. (1999) also found that the survival rate of nursing piglets was not affected by the level of dietary protein treatments. Similarly, Knabe et al. (1996), Stahly et al. (1990), Johnston et al. (1993), Monegue et al. (1993), Weeden et al. (1994), Richert et al. (1997), and Touchette et al. (1998a) all reported that the level of dietary lysine did not affect litter size at weaning. The average initial weights of the piglets and litter weight gains were not significantly different among the three treatments. Marginally greater average weight of weaned piglets ($p<0.10$) and daily gain of piglets ($p<0.11$) were observed with the 15% protein diet. There were no significant differences between the 13% protein diets in the average weight of the weaned piglets or the daily gain of the piglets. Knabe et al. (1996) reported that a 13% crude protein corn-soybean meal containing 0.60% lysine is inadequate for sows nursing large litters and that supplementation with synthetic lysine beyond 0.15% is not beneficial due to a deficiency of one or more other amino acids. Similarly, there was a tendency towards decreased litter weight gain and average daily weight gain of weanling piglets in lactating sows fed a diet containing 12.8% crude protein compared to a diet containing 14.8% crude protein (Yen and Cheng, 1995). We obtained a similar result in this study.

## REFERENCES


Baker, D. H. 2000. Recent advances in use of the ideal protein concept for swine feed formulation. Asian-Aus. J. Anim. Sci. 13(Special Issue):294-301.

Brendemuhl, J. H., A. J. Lewis and E. R. Peo, Jr. 1987. Effects of protein and energy intake by primiparous sows during lactation on sow and litter performance and sow serum thyroxine and urea concentrations. J. Anim. Sci. 64:1060-1069.

Brendemuhl, J. H., A. J. Lewis and E. R. Peo, Jr. 1989. Influence of energy and protein intake during lactation on body composition of primiparous sows. J. Anim. Sci. 67:1478-1488.

Chen, S. C., F. S. Chang and S. Y. Chen. 1990. Effect of essential amino acid level in lactation diets on lactation and reproductive performances of sows in a hot environment. Anim. Ind. Res. Inst. TSC. Annu. Res. Rept, (78/79). pp 99-104.

Chen, S. Y., J. P. F. D'Mello, F. W. H. Elsley and A. G. Taylor. 1978. Effect of dietary lysine levels on performance, nitrogen metabolism and plasma amino acid concentrations of lactating sows. Anim. Prod. 27:331-344.

Cheng, C. S., H. T. Yen, S. W. Roan and J. C. Hsu. 1999. Effect of reducing dietary protein and supplementing lysine during lactation on primiparous sows and litter performance. J. Chin. Soc. Anim. Sci. Vol. 28:269-275.

Cole, D. J. A. 1978. Amino acid nutrition of the pig. In: Recent Advances in Animal Nutrition-1978 (Ed. W. Haresign and D. Lewis) London, UK, Butterworths. pp 51-67.

Cole, D. J. A. 1991. The role of the nutritionist in designing feeds for the future. Pig News Info. 12:393-401.

Dourmad, J. Y., J. Noblet and M. Etienne. 1998. Effect of protein and lysine supply on performance, nitrogen balance, and body composition changes of sows during lactation. J. Anim. Sci. 76:542-550.

Ducan, D. B. 1955. Multiple range and multiple F test. Biometrics. 11:1-42.

Eastham, P. R., W. C. Smith, C. T. Whittemore and P. Phillips. 1988. Responses of lactating sows to food level. Anim. Prod. 46:71-77.

Han, In K. and J. H. Lee. 2000. The role of synthetic amino acids in monogastric animal production-review. Asian-Aus. J. Anim. Sci. 13(4):543-560.

Johnston, L. J., J. E. Pettigrew and J. W. Rust. 1993. Response of maternal-line sows to dietary protein concentration during lactation. J. Anim. Sci. 71:2151-2156.

Jones, D. B. and T. S. Stahly. 1995. Impact of amino acid nutrition during lactation on subsequent reproductive function of sows. J. Anim. Sci. 73(Suppl. 1):85(Abstr.).

King, R. H. 1987. Nutritional anestrus in young sows. Pig News Info. 8:15-22.

King, R. H. and A. C. Dunkin. 1986. The effect of nutrition on the reproductive performance of first-litter sows. 4.

The relative effects of energy and protein intakes during lactation on the performance of sows and their piglets. Anim Prod. 43:319-325.

King, R. H. and G. B. Martin. 1989. Relationships between protein intake during lactation, LH levels and oestrous activity in first-litter sows. Anim. Reprod. Sci. 19:283-292.

King, R. H., M. S. Toner, H. Dove, C. S. Atwood and W. G. Brown. 1993. The response of first-litter sows to dietary protein level during lactation. J. Anim. Sci. 71:2457-2463.

King, R. H. and I. H. Williams. 1984. The effect of nutrition on the reproductive performance of first-litter sows. 2. Protein and energy intakes during lactation. Anim. Prod. 38:249-256.

Knabe, D. A., L. I. Chiba, M. T. Coffey and C. R. Dove. 1996. Supplemental lysine for sows nursing large litters. J. Anim. Sci. 74:1635-1640.

Monegue, H. J., G. L. Cromwell, R. D. Coffey, S. D. Carter and M. Cervantes. 1993. Elevated dietary lysine levels for sows nursing large litters. J. Anim. Sci. 71(Suppl. 1):67(Abstr.).

Noblet, J. and M. Etienne. 1987. Metabolic utilization of energy and maintenance requirements in lactating sows. J. Anim. Sci. 64:774-781.

NRC. 1998. Nutrient Requirements of Swine (10th Ed.). National Academy Press, Washington, DC.

Richert, B. T., M. D. Tokach, R. D. Goodband, J. L. Nelssen, R. G. Campbell and S. Kershaw. 1997. The effect of dietary lysine and valine fed during lactation on sow and litter performance. J. Anim. Sci. 75:1853-1860.

SAS Institute Inc. 1988. SAS/STAT® User's Guide (Release 6.03). SAS Institute Inc., Cary, North Carolina.

Stahly, T. S., G. L. Cromwell and H. J. Monegue. 1990. Lactational responses of sows nursing large litters to dietary lysine levels. J. Anim. Sci. 68(Sppl. 1):369 (Abstr.).

Taylor, A. J., D. J. A. Cole and D. Lewis. 1979. Amino acid requirements of growing pigs. 1. Effects of reducing protein level in diets containing high levels of lysine. Anim. Prod. 29:327-338.

Touchette, K. J., G. L. Allee, M. D. Newcomb and R. D. Boyd. 1998a. The lysine requirement of lactating primiparous sows. J. Anim. Sci. 76:1091-1097.

Touchette, K. J., G. L. Allee, M. D. Newcomb and R. D. Boyd. 1998b. The use of synthetic lysine in the diet of lactating sows. J. Anim. Sci. 76:1437-1442.

Weeden, T. L., J. L. Nelssen, R. C. Thaler, G. E. Fitzner and R. D. Goodband. 1994. Effect of dietary protein and supplemental soybean oil fed during lactation on sow and litter performance through two parities. Anim. Feed Sci. Technol. 45:211-218.

Yen, H. T. and C. S. Cheng. 1995. The effect of dietary protein on the performance of prolific lactating sows and their piglets. J. Agric. Assoc. China New Series. 169:145-153.