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NGUYEN DINH TUONG

DETERMINATION OF APPROPRIATE DIETARY DIGESTIBLE LYSINE/METABOLIZABLE ENERGY RATIO AND FEEDING METHOD FOR F1(LANDRACE X YORKSHIRE) SOWS

MAJOR: Animal feed and Nutrition

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SUMMARY OF DISSERTATION

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Supervisors:

1. Dr. Tran Thi Bich Ngoc
2. Assoc. Prof. Dr Tran Hiep

Reviewer 1: Assoc. Prof. Dr Nguyen Thi Thuy My

Reviewer 2: Assoc. Prof. Dr Nguyen Hung Quang

Reviewer 3: Dr. Pham Cong Thieu

The thesis will be presented to the PhD thesis committee at the: National Institute of Animal Science lever at…hour…day….month……year 2022

More informations:

- National Library of Vietnam
- Library of National Institute of Animal Science

LIST OF PUBLICATIONS

1. Nguyen Dinh Tuong, Tran Thi Bich Ngoc, Tran Hiep and Pham Kim Dang (2021). Effect of Digestible Lysine/Metabolisable Energy Ratio in F1 (Landrace x Yorkshire) Gilt Diets on Growth, Age at Puberty and Reproductive Performance in Closed Housing Condition. Advances in Animal and Veterinary Sciences, September 2021, Volume 9, Issue 9, Page 1347-1354.

2. Nguyen Dinh Tuong, Pham Kim Dang, Tran Hiep and Tran Thi Bich Ngoc (2021). Determination of appropriate digestible lysine/metabolisable energy ratio in the diet of gestating sows under the open and close housing conditions. Vietnam Journal of Agricultural Sciences, N^{o} 19 (01.21): 33-41.

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INTRODUCTION

Problem statement

In recent years, genetic progress in pig breeds has improved dramatically. Reproductive performance of PIC sows increased from 26.5 to 30.6 piglets/sow/year, average weight increased by 20 g/day, lean percentage increased by 0.5%, number of newborns/litter increased by 0,2 piglets (The Pig Site, 2018; Merks, 2018).

According to statistics of the Department of Livestock Production (2021), the total pig herd of Vietnam currently has over 22 million heads, of which there are nearly 3.1 million sows (including local and exotic sows) with average productivity about 18-19 piglets weaned/sow/year. For exotic sows, the two main breeds used in Vietnam are Landrace sows and Yorkshire sows. Many studies show that the reproductive productivity of Landrace, Yorkshire and the cross between these two breeds raised in farm conditions is only on average of 22.63-22.85 weaned piglets /sow/year (Le Dinh Phung, 2009; Tran Thi Bich Ngoc, 2019; Ho Thi Bich Ngoc et al., 2020), lower than their potential. The productivity of these breeds is maintained at a high level with high yielding lines and raised in several breeding centers (25.8-27.1 weaners/sow/year) (Doan Phuong Thuy et al., 2015; Nguyen Thi Hong Nhung et al., 2020). There are many factors affecting the reproductive performance of pigs (breeding, environment, nutrition, feeding, management ...), in which feeding is one of the most important factors, directly affecting the embryo survival and neonatal survival (Costa et al., 2019).

Maternal nutrition affects fetal growth and development as well as postnatal performance and health (Wu et al., 2004; Cerisuelo

et al., 2009). Yang et al. (2009), Gómez-Carballar et al. (2013) suggested that increasing the ratio of total lysine/ME in the diet of pregnant sows increased the birth weight. Similarly, Heo et al. (2008) reported that diets with high lysine levels improved birth weight and weaned piglets.

On the other hand, maximizing the feed intake of the sow during the lactation period is very importance. Increasing feed intake will increase milk production, reduce maternal weight loss, reduce weaning – mating interval, and especially increase piglet weight at weaning (Whitney, 2010; Hawe et al., 2020). Whitney (2010) reported that, lactating sows should be fed at least 2 times/day but preferably 3 to 4 times/day. According to Baudon and Hancock (2003), feed pellets increased feed efficiency due to its dry matter, protein and energy digestibility, and reduced nitrogen excretion, thereby less reducing back fat thickness of the sow and reduce weaning – mating interval. On the other hand, feed pellets can increase palatability, increase nutrient density/kg feed, increase digestibility and reduce feed drop (Mavromichalis, 2007), thereby increasing the amount of nutrient intake.

Pig breeds in the world are always improved and imported to Vietnam, nutrition needs, therefore, to be improved to meet the genetic improvement of some popular exotic breed today. However, feed for sows on Vietnamese farms has a high level of nutrition, especially the wide range of dietary digestible lysine/energy metabolism ratio and sow are fed with variety methods (number of meals, feed form..). Therefore, determination of appropriate Dig.Lys/ME ratio and feeding

method is necessary to improve feed efficiency and productivity in sow production.

Objectives

- To determine appropriate digestible lysine/metabolisable energy (Dig.Lys/ME) ratio in diets of F1(Landrace x Yorkshire) sows at different physiological periods (gilt, gestation and lactation).

- To evaluate effect of feeding method at lactating period on reproductive performance and efficiency of sow production.

- To evaluate effect of diet with appropriate Dig.Lys/ME ratio and feeding method on reproductive performance and efficiency of F1(Landrace x Yorkshire) sow production.

Significance/Innovation of the dissertation

The present study has determined the appropriate Dig.Lys/ME ratio for gilts from 30 - 60 kg; 60 kg - first mating; gestating and lactating period in both open and close housing conditions were 2.81; 2.44; 1.96 and 2.75 g/Mcal.

The frequency of feeding sows 4 times/day with pellets increased the weight of weaned piglets in both open and close housing conditions.

Scientific and practical significance

Scientific significance

The present study has determined the appropriate Dig.Lys/ME ratio in the diet of F1(LY) sows in each physiological phases (gilts, gestation and lactation). The Dig.Lys/ME ratio meet both protein and energy requirement for the reproductive functions of F1(LY) sows. The study also provided a suitable feeding method for raising lactating sows.

Results of the thesis provided scientific basis to contribute to raising sows with high economic efficiency. At the same time, the research results are references for further studies, as teaching materials for training institutions.

Practical significance

Applying diets with appropriate Dig.Lys/ME ratio for each stage has improved reproductive performance of sows, this result will contribute to reducing the total number of sows in the pig herd structure of Vietnam. The research results are easily applied in practice condition and will provide high productivity and efficiency, waste and environmental pollution reduction.

CHAPTER I: LITERATURE REVIEW

It is reported that, the tendancy of the increase in nutrient density (NRC, 1998, 2012; Denmark, 2008, 2010), especially the digestible lysine/ME ratio are possibly due to the improvement of genetic progress of the sow, the nutritional needs need to be changed accordingly.

For gilts, several authors recommended the appropriate lysine ratio and energy level in the diet to achieve a weight gain rate that is conducive to optimal reproductive performance. Young (2003) reported that pigs of 25-50; 50-75; 75-90 and 90-115kg, the dietary lysine level is 1.15; 1.05; 0.9 and 0.8%, respectively while pigs were fed a dietary energy level of 14 MJ DE/kg for the whole period. Bikker et al. (1994) suggested that, the optimal ratio of Dig.Lys/DE for gilts of 20-45 kg were 0.63 and 0.61 g Dig.Lys/MJ DE. According to Gill (2006), the optimal ratio of Dig.Lys/DE for gilts of 30-50kg period,

50kg-first mating period was 0.41-0.83 and 0.37-0.74 g Dig.Lys/MJ DE.

For gestating sows, reasonable weight gain of sows prevents loss of body mass during lactation and avoids delay in return to estrus. Cooper (2001) reported that, the lysine ratio of 0.44% and 0.55% with 3100 kcal DE/kg did not affect the increase in body weight of sows. Yang et al. (2009) fed diets containing 0.6% and 0.8% lysine to gestating sows, the body weight, back fat thickness and total litter weight increased in the high lysine group and there was no difference in total body weight, number of born. Goncalves et al. (2016) showed similar results when feeding pregnant sows high lysine (20 g/day SID Lys) and high energy (64 Mcal NE/day) diets had a positive effect on sow weight and but no effect on the number of piglets born (similar results in authors Zhang et al. (2011) with lysine level of 0.65%-0.75%; Kusina et al. (999) with lysine level of 16 g/day).

For lactating sows, energy restriction can increase sow weight loss, decrease piglet weight at weaning, and increase time to return to estrus. However, increasing dietary energy reduced feed intake of lactating sows and decreased lysine intake (Beyer et al., 2007; Park et al., 2008). Shi et al. (2015) reported that with a diet of 3,325 kcal ME/kg, the ideal digestible lysine is at least 0.85%. Similarly, Xue et al. (2012) reported that a diet with 0,86% ideal digestible lysine and 3250 kcal ME/kg should be formulated. Camilla et al. (2019) reported that, at a density of 3,356 kcal ME/kg, the ideal digestible lysine level was 0.81%-0.91%.

Increasing feed intake of lactating sows will increase the weaning weight of piglets (Hawe et al., 2020; Sulabo et al., 2014). Whitney (2010) suggested that lactating sows should be fed at least 2 times/day

but preferably 3 to 4 times/day. According to Baudon and Hancock (2003), feed pellets increased feed efficiency due to its higher dry matter, protein and energy digestibility, and at the same time, reduced nitrogen excretion, thereby less reducing back fat thickness and reduce the time to return to estrus.

RESEARCH QUESTIONS AND HYPOTHESES

Research questions

- Appropriate Dig.Lys/ME ratio in the diet of F1(LY) sows in different physiological period (gilt, gestation and lactation)?

- How to feed lactating sows to achieve optimal feeding levels, in order to increase survival rate and piglet weight at weaning?

Research hypotheses

- Diet for gilts, gestating and lactating sows has a higher Dig.Lys/ME ratio than the recommendation of NRC standard (2012).

- Feeding lactating sows with pellet feed and several meals/day will increase the survival rate and piglet weight at weaning.

CHAPTER 2. MATERIALS AND METHODS

Animals

F1(LY) sows in different physiological periods (gilt, gestation and lactation).

Research time and location

Research time: From 2016 to 2020.

Research locations: A pig farm of Thai Duong Animal Feed Joint Stock Company (close housing condition, Ba Vi - Hanoi) and a pig farm of Ha Thai Trading and Production Joint Stock Company (open housing condition, Pho Yen - Thai Nguyen).

Contents

- Determination of appropriate Dig.Lys/ME ratio in the diets of F1(LY) sows at different physiological periods (gilt, gestation and lactation) in open and close housing conditions.

- Evaluation of effects of feeding method for lactating sows on reproductive performance.

- Trials to evaluate effect of diet with appropriate Dig.Lys/ME and feeding method on reproductive performace and efficiency of F1(LY) sow production.

In which: *Dig.Lys is apparent ideal digestible lysine. Dig.Lys/ME ratio was based on surveyed results (Trần Thị Bích Ngọc, 2019), NRC (2012) and US Pork Center of Excellence (2010).*

Methodology

Determination of appropriate Dig.Lys/ME ratio in the diets of F1(LY) sow

Determination of appropriate Dig.Lys/ME ratio in the diets of F1(LY) gilts

Table 2.1. Experimental design on gilts

Items	**Dig.Lys/ME ratio** (g/Mcal)		
	Low	**Medium**	**High**
Total animal (head/treatment)	24	24	24
Animal/replicate (head)	6	6	6
Replications (n)	4	4	4
Experimental time (months)	10	10	10
Peeriod 30 - 60kg			
Dietary crude protein (%)	17.0	17.0	17.0
Dig.Lys/ME ratio (g/Mcal)	2.34	2.58	2.81
Peeriod 60kg – first mating (from 220-240 days old, 110-140kg)			
Dietary crude protein (%)	15.0	15.0	15.0
Dig.Lys/ME ratio (g/Mcal)	2.03	2.24	2.44
From mating sow to weaning piglets (24 days old), pigs in all treatments were fed the same diet.			

Measurements:

- On gilts: At the beginning of the experiment, 60kg, first estrus, first mating, pigs were balanced with an electronic balance (Rud Weight, Australia) and measured the back fat thickness at first-mating time using an ultrasound machine (ultrasonic) at P2 point (the 10th rib, 6.5cm on both sides and perpendicular to the dorsal spine) (Renco LEAN -METER®) (Renco Corporation, Minneapolis, MN, USA). Feed offer and refusal were weighed daily.

- *In breeding sows:* Sows were weighed just after farrowing and weaning time of piglets. Newborn weight, number of born alive, weaned piglets, weaned piglet weight, weaning - re-mating interval were determined.

Criteria determined: daily weight gain (ADG), feed intake, feed conversion ratio (FCR), age at firth estrus and first mating, sow wight loss; number of born and born alive/litter; piglet weight, number and weight of weaned piglets (per piglet and per litter); weaning - re-mating interval. Feed conversion ratio /kg of weaned piglets: feed of sows (during gestation, lactation period) and of piglets.

Analysis of feed samples: Samples of feed and feed ingredients were analyzed for dry matter, crude protein, crude fiber, crude fat and total minerals according to the standards of AOAC (1990). Metabolic energy (ME) value of feed was calculated according to Noblet and Perez's (1993) formula: ME(kcal/kg) = 4.369 - 10.9 × Ash + 4.1 × EE - 6.5 × CF (R^2 = 0.87 and RSD = 90; nutrients in formula in g/kg CK). Total amino acids in feed ingredients were analyzed according to TCVN 8764:2012, the ratio of apparent ileal digestible amino acids of

the diet was calculated based on feed ingredients referenced from NRC (2012). All samples analyzed were performed at the National Institute of Animal Science.

Statistical analysis: Data were analyzed by one-way ANOVA (Minitab 16.0 statistical software).

Determination of appropriate Dig.Lys/ME ratio in the diets of F1(LY) gestating sows

Table 2.3. Experimental design on gestating sows

Chỉ tiêu	**Dig.Lys/ME ratio** (g/Mcal)		
	Low (1.56)	**Medium (1.76)**	**High (1.95)**
Total animal (head/treatment)	10	10	10
Animal/replicate (head)	1	1	1
Replications (n)	10	10	10
ME (kcal/kg)	3,013	3,008	3,002
Dietary crude protein (%)	13.54	13.55	13.57
Dig.Lys/ME ratio (g/Mcal)	1.56	1.76	1.95

Sows in the lactation period were fed the same diet in all treatments, piglets were weaned at 24 days of age.

Measurements:

Feed offer and refusal were weighed daily.

Sow body weight was determined at farrowing and weaning time of piglet. Piglet weight was determined at birth and weaning time. Number of newborn piglets, newborn alive piglets, weaned piglets per litter, and weaning – mating interval were determined by direct counting.

Criteria determined: Daily intake (dry matter, Dig.Lys), feed conversiton ratio (kg feed/kg weaned piglets). Sow weight loss, Number of newborn piglets, newborn alive piglets, weaned piglets per litter, and weaning – mating interval.

Analysis of feed samples: Similar to section 2.4.1.1.

Statistical analysis: Similar to section 2.4.1.1

Determination of appropriate Dig.Lys/ME ratio in the diets of F1(LY) lactating sows

Table 2.5. Experimental design on lactating sow

Chỉ tiêu	**Dig.Lys/ME ratio** (g/Mcal)		
	Low (2.29)	**Medium (2.51)**	**High (2.75)**
Total animal (head/treatment)	10	10	10
Animal/replicate (head)	1	1	1
Replications (n)	10	10	10
ME (kcal/kg)	3,259	3,257	3,256
Dietary crude protein (%)	18.06	18.06	18.06
Dig.Lys/ME ratio (g/Mcal)	2.29	2.51	2.75
Piglets were fed the same diet in all treatments.			

Measurements: Similar to section 2.4.1.2

Feed conversion ratio (kg feed per kg of weaned piglets) was calculated based on the feed consumption of lactating sow and feed consumption of piglets.

Analysis of feed samples: Similar to section 2.4.1.1.

Statistical analysis: Similar to section 2.4.1.1

Evaluation of effect of feeding method for lactating sows on reproductive performance

Table 2.7. Feeding method experimental design

Chỉ tiêu	EX1	EX 2	EX3	EX4
Total animal (head/treatment)	10	10	10	10
Animal/replicate (head)	1	1	1	1
Replications (n)	10	10	10	10
Feeding method	pellet, 2 meal dailly	pellet, 4 meal dailly	powder, 2 meal dailly	powder, 4 meal dailly

Measurements: Similar to sections 2.4.1.2, 2.4.1.3.

Analysis of feed samples: Similar to section 2.4.1.1.

Statistical analysis: Data were analyzed by general linear model using Minitab 16.0 statistical software.

Trial of feeding appropriate Dig.Lys/ME ratio diets of gilt, gestating and lactacting sows in combination with suitable feeding method for lactating sow

Table 2.9. Feeding trial experimental design

Items	Control group	Ex.group
Period 30kg – first mating		
Total animal (head/treatment)	24	24
Animal/replicate (head)	8	8
Replications (n)	3	3
Period 30 - 60kg		
Dietary crude protein (%)	16.81	17.0
Dig.Lys/ME ratio (g/Mcal)	2.34	2.81
Period 60kg – first mating (from 220-240 dals old, 110-140kg)		
Dietary crude protein (%)	15.14	15.0
Dig.Lys/ME ratio (g/Mcal)	2.03	2.44
Gestating sow		
Total animal (head/treatment)	24	24
Animal/replicate (head)	1	1
Replications (n)	24	24
Dietary crude protein (%)	13.81	13.57
Dig.Lys/ME ratio (g/Mcal)	1.56	1.95
Lactating sow		
Total animal (head/treatment)	24	24
Animal/replicate (head)	1	1
Replications (n)	24	24
Dietary crude protein (%)	16.39	18.00
Dig.Lys/ME ratio (g/Mcal)	2.32	2.75
Feeding method*	pellet, 2 meal dailly	pellet, 4 meal dailly

Creteria determination: The criteria in this experiment were determined similarly to the experiment on pigs in the gilt, gestation and 1st lactation.

Analysis of feed samples: Similar to section 2.4.1.1.

Statistical analysis: Data were analyzed by one-way ANOVA using Minitab 16.0 statistical software.

CHAPTER III: RESULTS AND DISCUSION

Determination of appropriate Dig.Lys/ME ratio in the diets of F1(LY) sow

Determination of appropriate Dig.Lys/ME ratio in the diets of F1(LY) gilts

Effect of dietary Dig.Lys/ME ratio on growth rate, back fat thickness and sexual maturity age

Results on growth performance of gilts showed that, gilts fed diets with medium and high Dig.Lys/ME ratio had the highest body weight at first estrus and first mating ($p<0.05$). Body weight at the end of phase 1, at the time of first estrus and first mating were significantly different between different dietary Dig.Lys/ME ratio ($p<0.05$) in both close and open housing conditions.

Effect on growth rate:

The group fed diets with medium and high Dig.Lys/ME ratios had higher weight gain than those fed diets with low Dig.Lys/ME ratio ($p<0.05$). However, from first estrus to mating, dietary Dig.Lys/ME ratio did not affect daily weight gain of gilts ($p>0.05$).

Table 3.1. Growth rate of gilts in open housing conditions

Items	**Dig.Lys/ME ratio** (g/Mcal)			SEM	p
	Low	**Medium**	**High**		
Body weight (kg)					
Initial weight	29.58	29.84	29.56	0.91	0.970
Weight at phase 1	60.48^{b}	62.94^{a}	63.64^{a}	0.69	0.003
Weight at first estrus	104.23^{b}	107.87^{a}	108.25^{a}	1.00	0.007
Weight at first mating	133.15^{b}	136.78^{a}	138.31^{a}	1.09	0.003
Average daily gain (g/head/day)					
Period 1 (30-60kg)	630^{b}	671^{ab}	693^{a}	14.59	0.008
Period 2 (60kg-first estrus)	687^{b}	727^{ab}	750^{a}	17.47	0.030
Period 3 (first estrus - first mating)	629	636	652	14.36	0.480
Average	650^{b}	681^{a}	700^{a}	12.64	<0.001

Note: Different letters in the same row represent a statistically significant difference ($p<0.05$).

Table 3.2. Growth rate of gilts in close housing conditions

Items	Dig.Lys/ME ratio (g/Mcal)			SEM	p
	Low	Medium	High		
Body weight (kg)					
Initial weight	29.31	29.85	29.77	0.79	0.872
Weight at phase 1	61.60^{b}	64.04^{ab}	65.06^{a}	0.74	0.005
Weight at first estrus	105.17^{b}	108.23^{ab}	109.78^{a}	0.91	0.002
Weight at first mating	135.09^{b}	138.45^{ab}	139.96^{a}	1.10	0.008
Average daily gain (g/head/day)					
Period 1 (30-60kg)	651^{b}	691^{a}	708^{a}	11.54	0.003
Period 2 (60kg-first estrus)	667^{b}	707^{ab}	732^{a}	16.03	0.020
Period 3 (first estrus - first mating)	651	655	659	15.81	0.950
Average	655^{b}	684^{a}	701^{a}	8.56	<0.001

Note: Different letters in the same row represent a statistically significant difference (p<0.05).

Effect on back fat thickness and sexual maturity age:

Age at first estrus and first mating tended to decrease as Dig.Lys/ME ratio increased in the diet. The sows fed a diet with high Dig.Lys/ME ratio had the earliest age at first estrus and first mating, followed by the sows fed medium and low Dig.Lys/ME ratio.

The Dig.Lys/ME ratio in the diet affected back fat thickness at first mating ($p<0.05$), with the highest value in the group of pigs fed the high Dig.Lys/ME ratio diet, followed by the group fed the medium ratio, the lowest in the group fed the low Dig.Lys/ME ratio in the diet. However, back fat thickness at first estrus was not affected by the Dig.Lys/ME ratio in the diet.

Effect of dietary Dig.Lys/ME ratio on feed intake and feed utilization efficiency

The results show that, as a general tendency, FCR increases gradually over the stages in both close and open housing conditions. When considering the effect of dietary Dig.Lys/ME ratio on feed intake and FCR, the results show that FCR tended to decrease gradually with increasing Dig.Lys/ME ratio, however, there was no

significant difference between the low, medium and high Dig.Lys/ME ratios.

Effect of dietary Dig.Lys/ME ratio on reproductive performance

The results of the reproductive performance of the first parity showed that, the number of alive piglets/litter was not significantly different between treatments (p>0.05), but the number of weaned pigs/litter, birth weight and weaned weight were higher in group of sow fed diets with high and average Dig.Lys/ME ratio, compared with those of sow fed diets with low Dig.Lys/ME ratio (p<0.05).

Table 3.9. Reproductive performance at first parity in open housing condition

Items	**Dig.Lys/ME ratio** (g/Mcal)			SEM	p
	Low	**Medium**	**High**		
Number of born/litter	10.26	10.62	10.78	0.217	0.200
Number of born alive/litter	9.39^{b}	9.86^{a}	9.96^{a}	0.175	0.045
Alive rate until weaning time (%)	91.52	92.84	92.39	-	-
Birth weight/litter (kg)	13.80^{b}	14.46^{ab}	15.14^{a}	0.289	0.004
Birth weight/piglet (kg)	1.28	1.31	1.33	0.017	0.099
Weaning weight/litter (kg)	57.54^{b}	63.16^{a}	63.80^{a}	1.074	<0.001
Weaning weight/piglet (kg)	6.14^{b}	6.41^{a}	6.43^{a}	0.077	0.012

Note: Different letters in the same row represent a statistically significant difference (p<0.05).

Table 3.10. Reproductive performance at first parity in close housing condition

Items	**Dig.Lys/ME** (g/Mcal)			SEM	p
	Low	**Medium**	**High**		
Number of born/litter	10.74	11.04	11.22	0.223	0.313
Number of born alive/litter	9.83^{b}	10.26^{ab}	10.39^{a}	0.157	0.034
Alive rate until weaning time (%)	91.61	92.93	92.60	-	-
Birth weight/litter (kg)	14.60^{b}	15.31^{ab}	15.91^{a}	0.301	0.012
Birth weight/piglet (kg)	1.36^{b}	1.39^{ab}	1.42^{a}	0.017	0.034
Weaning weight/litter (kg)	62.30^{b}	66.69^{a}	68.34^{a}	0.937	<0.001
Weaning weight/piglet (kg)	6.35^{b}	6.51^{ab}	6.58^{a}	0.053	0.009

Note: Different letters in the same row represent a statistically significant difference (p<0.05).

Results showed that the increase in dietary Dig.Lys/ME ratio reduced feed conversion ratio (calculated as kg of feed/1 kg of weaned piglets) (reduced from 6.86 to 6.30 kg in open housing condition and from 6.47 to 5.92 kg in close housing conditions) ($p<0.05$). Average daily gain of piglet during the maternal period was significantly higher in group of sows fed with medium and high dietarry Dig.Lys/ME ratio ($p<0.05$) .

Determination of appropriate Dig.Lys/ME ratio in the diets of F1(LY) gestating sow

Effect of dietary Dig.Lys/ME ratio on reproductive performance

The dietary Dig.Lys/ME ratio of gestating sows's diet in both open and close housing conditions had a significant effect on birth weight and weaning weight per litter, as well as per piglet ($p<0.05$). Increasing the dietary Dig.Lys/ME ratio from 1.56 to 1.95 g/Mcal increased birth weight and weaning weight per litter by 5.77% to 14.88%, and per piglet by 2.15% to 9.22%.

Table 3.15. Reproductive performance in open housing condition

Items	**Dig.Lys/ME** (g/Mcal)			SEM	p
	Low (1.56)	**Medium (1.76)**	**High (1.95)**		
n	10	10	10		
Number of born/litter	11.8	12.0	12.1	0.347	0.825
Number of born alive/litter	10.5	10.9	11.2	0.265	0.192
Alive rate until weaning time (%)	89.32	91.01	92.78	1.668	0.356
Birth weight/litter (kg)	16.30	17.24	17.91	0.526	0.112
Birth weight/piglet (kg)	1.39^{b}	1.44^{ab}	1.48^{a}	0.027	0.048
Weaning weight/litter (kg)	68.34^{b}	72.52^{b}	78.51^{a}	1.482	<0.001
Weaning weight/piglet (kg)	6.52^{b}	6.66^{ab}	7.03^{a}	0.107	0.007
ADG (g/piglet/day)	214.1^{b}	217.6^{ab}	231.1^{a}	6.180	0.025

Note: ADG: Average daily gain; Different letters in the same row represent a statistically significant difference ($p<0.05$).

Table 3.16. Reproductive performance in close housing condition

Chỉ tiêu	**Dig.Lys/ME** (g/Mcal)			SEM	p
	Low (1.56)	**Medium (1.76)**	**High (1.95)**		
n	10	10	10		
Number of born/litter	12.1	12.3	12.4	0.382	0.853
Number of born alive/litter	10.7	11.3	11.5	0.263	0.101
Alive rate until weaning time (%)	88.72	92.23	93.12	1.685	0.168
Birth weight/litter (kg)	17.03^{b}	18.18^{ab}	19.08^{a}	0.515	0.031
Birth weight/piglet (kg)	1.41^{b}	1.49^{ab}	1.54^{a}	0.035	0.044
Weaning weight/litter (kg)	70.79^{b}	76.73^{a}	81.17^{a}	1.543	<0.001
Weaning weight/piglet (kg)	6.62^{b}	6.81^{ab}	7.09^{a}	0.122	0.042
ADG (g/piglet/day)	217.1	221.6	230.8	5.74	0.153

Note: ADG: Average daily gain; Different letters in the same row represent a statistically significant difference (p<0.05).

Effect of dietary Dig.Lys/ME ratio on feed utilization efficiency

In both open and close housing conditions, the daily digestible lysine intake of gestating sows increased as the dietary Dig.Lys/ME ratio increased (p<0.05). The daily digestible lysine intake ranged from 11.23 to 14.46 g/head/day.

Increasing the dietary Dig.Lys/ME ratio from 1.56 to 1.95 g/Mcal reduced FCR (kg of feed per 1kg of weaned piglets) from 5.93 to 5.25 kg in open housing condition and from 5.84 to 5.18 kg in close housing condition) (p<0.05).

Effect of dietary Dig.Lys/ME ratio on body weight change and weaning – estrus interval

Increasing the Dig.Lys/ME ratio in the diet of gestating sows reduced body weight loss and weight loss rate of lactating sow (p<0.05). Sow's body weight loss during lactation in the group of gestating sows fed diets of medium (1.76 g/Mcal) and high (1.95 g/Mcal) Dig.Lys/ME ratio was lower than in the group fed low dietary Dig.Lys/ME ratio

(1.56 g/Mcal), by 12.60% and 19.72% in open housing condition, and by 14.33% and 19.20% in closed housing condition.

. Determination of appropriate Dig.Lys/ME ratio in the diets of F1(LY) lactating sow

Effect of dietary Dig.Lys/ME ratio on reprodctive performance and feed utilisation eficiency

Increasing dietary Dig.Lys/ME ratio increased weaning weight per litter and per piglet, and aveage daily gain of piglets in both open and close housing conditions ($p<0.05$).

Table 3.21. Effect of dietary Dig.Lys/ME ratio on reproductive performance in open housing condition

Items	**Dig.Lys/ME** (g/Mcal)			SEM	p
	Low (2.29)	**Medium (2.51)**	**High (2.75)**		
n	10	10	10		
Number of born/litter	11.40	11.60	11.50	0.43	0.947
Number of born alive/litter	10.10	10.70	10.70	0.33	0.343
Alive rate until weaning time (%)	89.15	92.79	93.13	2.13	0.356
Birth weight/litter (kg)	16.35	16.32	16.61	0.53	0.927
Birth weight/piglet (kg)	1.44	1.42	1.45	0.02	0.583
Weaning weight/litter (kg)	67.5^{b}	72.56^{a}	75.53^{a}	1.92	0.021
Weaning weight/piglet (kg)	6.69^{b}	6.79^{ab}	7.10^{a}	0.11	0.038
ADG (g/piglet/day)	218.9^{b}	224.0^{ab}	235.2^{a}	5.43	0.048

Note: ADG: Average daily gain; Different letters in the same row represent a statistically significant difference ($p<0.05$).

Increasing dietary Dig.Lys/ME ratio from 2.29 to 2.75 g/Mcal reduced feed conversion ratio (kg of feed per 1kg of weaned piglets) from 1.92 down to 1.75 kg in the open housing condition and form 1.79 down to 1.67 kg in close housing condition ($p<0.05$). However, feed conversion ratio did not differ between low (2.29 g) and medium (2.51 g), and between medium (2.51 g) and high (2.75 g) dietary Dig.Lys/ME ratio (g Dig.Lys/Mcal ME) ($p>0.05$).

Table 3.22. Effect of dietary Dig.Lys/ME ratio on reproductive performance in close housing condition

Items	**Dig.Lys/ME** (g/Mcal)			SEM	p
	Low (2.29)	**Medium (2.51)**	**High (2.75)**		
n	10	10	10		
Number of born/litter	12.50	12.50	12.40	0.37	0.975
Number of born alive/litter	11.20	11.60	11.60	0.29	0.467
Alive rate until weaning time (%)	89.76	93.01	93.90	1.59	0.168
Birth weight/litter (kg)	18.38	18.31	17.98	0.50	0.833
Birth weight/piglet (kg)	1.48	1.47	1.45	0.036	0.864
Weaning weight/litter (kg)	76.06^{b}	80.85^{ab}	82.47^{a}	1.75	0.040
Weaning weight/piglet (kg)	6.79^{b}	6.98^{ab}	7.12^{a}	0.067	0.010
ADG (g/piglet/day)	221.6^{b}	229.4^{ab}	236.0^{a}	4.94	0.010

Note: ADG: Average daily gain; Different letters in the same row represent a statistically significant difference (p<0.05).

Effect of dietary Dig.Lys/ME ratio on body weight change and weaning – estrus interval of lactating sow

Increasing the ratio of dietary Dig.Lys/ME reduced body weight loss and weight loss rate of sows during lactation (p<0.05). Body weight loss and weight loss rate in the group of lactating sow fed diets with level of 2.29; 2.51 and 2.75 g Dig.Lys/Mcal ME were 17.44; 14.99 and 14.32 kg and 6.94%; 5.98% and 5.63% in open house condition and 17.78; 15.69 and 15.14 kg and 7.02%; 6.22% and 5.94% in close housing condition. Sow's body weight loss during lactation in the group fed diets with 2.51 and 2.75 g Dig.Lys/ Mcal ME was lower than those in group fed diets with 2.29 g Dig.Lys/ Mcal ME, by 14.05% and 17.89% in open housing condition and by 11.75% and 14.85% in close housing condition, respectively.

Evaluation of effects of feeding method for lactating sows on reproductive performance

Effect of feed form and number of meals on reproductive performance and feed utilisation eficiency

In both open and close housing conditions, feed form and number of meals daily did not affect the survival rate of piglets (p>0.05). However, feed form and number of meals daily affected significantly the weaned weight (per litter, per piglet) and average daily weight of piglets (p<0.05). The group of sows fed pellets had higher weaning weight ((per litter, per piglet) and daily weight gain of piglets than in the group of sows fed powder feed.

Table 3.27. Effect of feed form and number of meals on reproductive performance in open housing condition

Items	Feed form		N° meals*		SEM	p	
	Powder	Pellet	2 meals	4 meals		Feed form	N° meals
n	20	20	20	20			
Number of born/litter	11.65	11.70	11.60	11.75	0.231	0.879	0.649
Number of born alive/litter	10.50	10.75	10.55	10.70	0.132	0.188	0.426
Alive rate until weaning time (%)	90.55	92.18	91.42	91.31	1.299	0.381	0.951
Birth weight/litter (kg)	16.12	15.82	15.82	16.12	0.349	0.984	0.547
Birth weight/piglet (kg)	1.37	1.37	1.36	1.37	0.016	0.778	0.677
Weaning weight/litter (kg)	67.89	72.75	68.46	72.17	0.81	0.001	0.003
Weaning weight/piglet (kg)	6.48	6.78	6.50	6.75	0.084	0.016	0.044
ADG (g/piglet/day)	212.7	225.5	214.1	224.1	3.20	0.010	0.041

*Note: *: Automatic feeder; ADG: Average daily gain.*

The daily feed intake during the lactation period of sow group fed powder feed was lower than in the group fed pellets in both open and close housing conditions, respectively by 4.41% and 5.18%, respectively (p<0.05). The daily feed intake in the sow group fed 4 meals daily was higher than the group fed 2 meals by 3.82% in the open housing condition and by 3.88% in the close housing condition (p<0.05). However, feed form and number of meals did not affect feed

conversion ratio (kg of feed /kg weaned piglets) (p>0.05) in both open and close housing conditions.

Table 3.28. Effect of feed form and number of meals on reproductive performance in close housing condition

Items	Feed form		Nº meals*		SEM	p	
	Powder	Pellet	2 meals	4 meals		Feed form	Nº meals
n	20	20	20	20			
Number of born/litter	12.45	12.55	12.55	12.45	0.263	0.790	0.790
Number of born alive/litter	11.35	11.55	11.40	11.50	0.172	0.417	0.684
Alive rate until weaning time (%)	91.65	92.31	91.16	92.80	1.41	0.745	0.416
Birth weight/litter (kg)	18.08	18.53	18.37	18.24	0.339	0.360	0.796
Birth weight/piglet (kg)	1.46	1.48	1.47	1.47	0.017	0.470	0.951
Weaning weight/litter (kg)	75.95	80.98	76.67	80.27	1.094	0.003	0.026
Weaning weight/piglet (kg)	6.70	7.02	6.73	6.98	0.060	0.001	0.006
ADG (g/piglet/day)	218.4	230.8	219.4	229.8	2.25	0.001	0.003

*Note: *: Automatic feeder; ADG: Average daily gain.*

The amount of feed consumed in the group of sows fed 4 meals was higher than in the group fed 2 meals. The weaning weight (per litter and per piglet) and daily weight gain of piglets increased by 5.4%; 3.85% and 4.67% in open housing condition and by 4.7%; 3.71% and 4.70% in close housing condition.

Trials to evaluate effect of diet with appropriate Dig.Lys/ME and feeding method (for lactating sow) on reproductive performace and efficiency of F1(LY) sow production

Growth rate of gilts

The results show that the weight at first estrus and at first mating of group of gilts fed the experimental diet (EX) was higher than that of group fed the control diet (Control) (farm procedure) in both open and close housing conditions (p<0.05).

Table 3.33. Growth rate of F1 (LY) gilts

Items	Open housing condition				Close housing condition			
	EX	Control	SEM	p	EX	Control	SEM	p
Body weight (kg)								
Initial weight	30,92	30,79	0,383	0,813	31,53	31,31	0,27	0,565
Weight at phase 1	63,46	61,37	0,750	0,006	65,88	63,37	0,39	<0,001
Weight at first estrus	108,45	104,35	0,721	0,001	110,55	106,70	0,72	<0,001
Weight at first mating	137,91	132,65	0,594	0,001	140,05	136,55	0,63	<0,001
Average daily gain (g/head/day)								
Period 1 (30-60kg)	664	624	11,44	0,017	701	654	5,93	<0,001
Period 2 (60kg-first estrus)	775	680	28,41	0,020	740	679	11,24	<0,001
Period 3 (first estrus-first mating)	666	662	59,75	0,963	626	629	25,04	0,927
Average	691	641	19,66	0,078	691	655	6,84	<0,001

Note: EX: Experiment group; Control: Control group.

The back fat thickness of gilts at first mating time in the EX group was higher than that in the Control group in both open and close housing conditions ($p<0.05$) and equivalent to the results of content 1 of this study.

Feed utilization efficiency of gilts

Feed consumption of gilts in both Control and EX groups increased over the physiological phases, consistent with the growth and development laws of pigs. Feed conversion ratio of gilts in the EX group (open housing and close housing condition) tended to be lower than that of the Control group ($p<0.05$) and similar to the results obtained in content 1 of the present study. The average feed conversion ratio of gilts in the EX group ranged from 3.64 to 3.65 kg.

First parity reproductive performance

The productivity of the first parity of sows in the EX group was higher than that in the Control group ($p<0.05$), as shown by indicators

such as the number of weaned pigs per litter, birth weight and weaning weight (per litter and per piglet).

The weaned weight of piglets of the EX group was 6.68 - 6.75 kg/piglet, higher than that of the Control group (6.40 - 6.47 kg/piglet) ($p<0.05$) and of results obtained in Content 1 of the present study (6.43 - 6.58 kg/piglet).

The daily weight gain of piglets in the Control group was 210 to 215 g/piglet/day, lower than that of the EX group (220 g/piglet/day) ($p<0.05$). The daily weight gain of piglets in EX group was also high than that obtained in Content 1 of the present study (212 and 215 g/piglet/day in the open and close housing contition, respectively).

Feed utilisation efficiency of gestating and lactating sows

Compared with the Control group, higher feed consumption and lower feed conversion ratio (kg of feed per kg weaned piglet) of piglet was found in EX group ($p<0.05$).

Feed conversion ratio (kg of feed per kg weaned piglet) in the EX group was lower than that in the Control group by 9.15% to 10.70% ($p<0.05$), and also lower than the results obtained in Content 1 of the present study (5.92 - 6.30 kg/kg).

CONCLUSIONS

1. Conclusions

- The appropriate Dig.Lys/ME ratio (calculated as g apparent ileal Dig.Lys/ME) in the diet of gilts at the 30-60 kg, 60 kg to first mating were 2.81 and 2.44 g/Mcal.

- The appropriate Dig.Lys/ME ratio in the diet of gestating sows was 1.76 - 1.95 g/Mcal.

- The appropriate Dig.Lys/ME ratio in the diet of lactating sows was 2.44 g/Mcal.

- Changing feed form from powder to pellets and changing feeding method frompå 2 meals to 4 meals for lactating sows improved feed intake and average daily gain of piglets (per litter and per piglet).

- Applying the results from the present study for F1(LY) gilt, gestating, lactating sows in both open and close housing conditions resulted in earlier sexual maturity and better reproductive performance compared with those in current procedure of farm (farm procedures) (age of first estrus: 183.63 and 185.08 days old vs 188.08 and 188.50 days old; number of weaning piglet per litter: 10.23 and 10.52 piglets *vs* 9.61 and 9.91 piglets; weaning weight/litter: 68.35 and 70.97 kg *vs* 61.42 and 64.05 kg).

2. Recommendations

F1(LY) sow breeding farms should formulate diets for gilts at 30 - 60 kg, 60 kg - mating, gestating and lactating period with the appropriate Dig.Lys/ME ratio are: 2.81, 2.44, 1.95 and 2.75 g/Mcal. Sows should be fed pellets and 4 times/day.