

# **Influence of Dietary Protein and Energy Levels on Sow Backfat Thickness**

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## **Abstract**

The objective of the present study was to determine the influences of dietary protein and energy levels on sow backfat thickness. The study was conducted by randomly measured backfat thickness in both pregnant and lactating stages of 10,401 sows from 7 commercial herds in Thailand. The pregnant sow diets contained 14.4% crude protein (CP) and 3,346 kcal metabolizable energy (ME)/kg. The lactating sow diet contained 18.8% CP and 3,660 kcal ME/kg. The percentage of dietary protein was positively correlated with backfat thickness ( $r = 0.036$ ,  $P < 0.01$ ) and the metabolizable energy of the diet was positively correlated ( $r = 0.053$ ,  $P < 0.01$ ). Upon, stepwise method of multiple linear regression analysis showed that the percentage of dietary crude fat ( $X$ , %) was a key factor affecting the thickness of sow backfat ( $Y$ , mm) with statistical significance. The regression equation was;  $Y = 14.4 + (0.2X)$ , ( $R^2 = 0.009$ ,  $P < 0.01$ ). Conclusion, a major nutritional factor that response for changing of sow backfat thickness was the dietary energy in sow diet.

**Keywords:** backfat thickness, protein, energy, sow

# อิทธิพลของระดับโปรตีนและพลังงานในอาหารต่อความหนาไขมันสันหลังในแม่สุกร

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## บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาอิทธิพลของระดับโปรตีนและพลังงานในสูตรอาหารแม่สุกรต่อความหนาไขมันสันหลังของแม่สุกรโดยได้ทำการสุ่มวัดข้อมูลความหนาไขมันสันหลังจากฟาร์มสุกรที่เลี้ยงเชิงพาณิชย์จำนวน 7 ฟาร์ม ในประเทศไทยจำนวนทั้งหมด 10,401 ตัวพบว่าจากการสุ่มอาหารวิเคราะห์หองค์ประกอบทางเคมีของสูตรอาหารแม่สุกรอู้มท้อง มีค่าเฉลี่ยได้แก่โปรตีนหยาบ 14.4 % CP และพลังงานที่ใช้ประโยชน์ได้ 3,346 Kcal ME/kg และสูตรอาหารแม่สุกรเลี้ยงลูก มีค่าเฉลี่ยได้แก่ 18.8 %CP และ 3,660 Kcal ME/kg ผลการศึกษาความสัมพันธ์พบว่า เปรอร์เซ็นต์โปรตีนของสูตรอาหารแม่สุกรมีความสัมพันธ์เชิงบวกกับความหนาไขมันสันหลังอย่างมีนัยสำคัญทางสถิติ ( $r = 0.036$ ,  $P < 0.01$ ) และค่าพลังงานที่ใช้ประโยชน์ได้ของสูตรอาหารมีความสัมพันธ์เชิงบวกกับความหนาไขมันสันหลังอย่างมีนัยสำคัญทางสถิติ ( $r = 0.053$ ,  $P < 0.01$ ) จากการทดลองเมื่อหาความสัมพันธ์ระหว่างองค์ประกอบทางเคมีของสูตรอาหารและค่าความหนาไขมันสันหลังเพื่อสร้างสมการถดถอยตามวิธี multiple linear regression analysis พบว่า ไขมันหยาบ (X, %) ในสูตรอาหารเป็นปัจจัยหลักที่มีผลต่อความหนาไขมันสันหลังแม่สุกร (Y, mm) อย่างมีนัยสำคัญทางสถิติ โดยมีสมการถดถอย คือ  $Y = 14.4 + (0.2X)$ , ( $R^2 = 0.009$ ,  $P < 0.01$ ) ดังนั้น จากผลการศึกษานี้สามารถสรุปได้ว่า อาหารพลังงานเป็นโทษหลักที่มีผลต่อการเปลี่ยนแปลงของความหนาไขมันสันหลังของแม่สุกร

คำสำคัญ: ความหนาไขมันสันหลัง โปรตีน พลังงานในอาหาร แม่สุกร

## Introduction

Swine production was important agri-business in Thailand as well as other countries in Southeast Asia. Thereby, swine diet was critical to swine health and their productivity and also was a major cost in swine production. Therefore, management of swine diet and feeding was crucial for pig farmers to optimum the plane of nutrition for different swine breeds, which could help farmers to be contended in the business of swine production. Development of pig farming in various fields, highlighted in genetics trait, in term of more productive lean aimed to meet the need of the swine market. However, these developments to meet market demand causing negative impact on subsequent, in particular, the swine breeding development of high lean and consequent low backfat sow performance. Thereby, those lowering on the backfat thickness had a negative impact on sow's productivity because backfat was stored for energy reserved during pregnancy and used for milk production after the parturition. Productivity of sow had many factors involved, such as the integrity of the body, age and parity sequence of sows. However, by focusing on integrity of the sow body in term of the body condition score (BCS) had much variation depend on the experience of the investigators. Recently, sow backfat thickness measurement approach was accepted to be more precision and accuracy than that of BCS. However, the criteria used to assess backfat thickness instead of BSC could be many factors involved, such as sow bred, parity and investigator evaluated (Kunavongkrit et al, 2002). There were many studies focus on the influence of the thickness of backfat of sows widely because of the importance of backfat thickness of sows on their productivity. De Rensis et al. (2005) showed that backfat thickness loss during piglet rearing associated with reproductive performance after weaning of sows. For study in Thailand, Tummaruk et al. (2007) found that age, body weight and backfat thickness in gilts, were influenced on litter size and number of born alive during first to third parity, he concluded that backfat

thickness of sows was important factor to the reproductive performance of sows. While other studies from European countries revealed the relationship between backfat thickness and reproductive performance of sows, however, the environment was different between Thailand and that of mentioned studies so that those relationships could not be used to extrapolate directly to the swine production practice in Thailand. Factors affecting backfat thickness may be summarized as two main factors, including genetics and nutrition. On the other hand, the genetics factor may not fully control because of breeding was aimed to have less backfat thickness but more lean carcass as market proposed. Since 1999, breeding proposed focusing on the breeding conditions of the backfat thickness of about 12 mm (Imboonta et al., 2007). Therefore, the sow nutritional manipulation in term of adjusting the concentration of dietary protein and energy in sow diets was a possible factor which farmers were able to do so in practice. Currently, Thailand did not have any research on the influence of diet on backfat thickness of sow, hence, it was interesting to know whether dietary protein or energy level response to be a major nutritional factor for changing of sow backfat thickness under commercial pig herds.

## Materials and Methods

### Experimental animal and data collection

This survey study was to collect data of backfat thickness and their diets of sows by sampling data from seven commercial swine farms, which randomly measured backfat thickness of both pregnant and lactating sows for the total number of 10,401 heads. The random measurement of backfat thickness at the location of the back side, last rib (P2) both left and right sides (Kunavongkrit et al., 2002) of sows by using a digital backfat meter (Ultrasound Renco®, USA). Sows were physiologically divided into 11 groups; mating sows, post mating sows, 4 weeks pregnant sows, 8 weeks pregnant sows, 12 weeks pregnant sows, pre-farrowing sows,

lactating 1 week sows, lactating 2 weeks sows, lactating 3 weeks sows, lactating 4 weeks sows and weaning sows. Abide by the status of the sow at the time to measure backfat thickness per farm a month for 12 consecutive months to increase the number of sows repeating as much as possible to reduce the confounding effects. Both pregnant and lactating sow diets were randomly sampled for each 5 samples for each 500 grams to analyze chemical composition. However, individual diets dry matter intakes of sows were not recorded due to sow keeper in each farm adjusted the quantity of diet offered as the sow body condition present.

### **Chemical analyses**

Both pregnant and lactating sow diets from each 5 samples in each farm and in each month were pooled prior to estimate by proximate analysis method, including contents of moisture, dry matter (DM), crude protein (CP), crude fat (ether extract, EE), crude fiber (CF), ash and crude carbohydrate (nitrogen free extract, NFE) as the percentage. The analysis was based on the method of the Association of Official Analytical Chemists (AOAC, 1984, 2001) and performed at the animal nutrition laboratory, faculty of veterinary science, Mahidol University. Thereby, all analyzed chemicals contents were subjected to calculate the digestible energy (DE, kcal/kg) and metabolizable energy (ME, kcal/kg), according to the NRC (1998).

### **Statistical analyses**

Whole data set of backfat thickness of sows was calculated into descriptive statistics. Then observed parameters of backfat thickness of sows and analyzed

chemical proximate analysis of sow diets, were showed the arithmetic mean in term of mean  $\pm$  standard error (SE) for each sow status. In addition, data set was analyzed to reveal the relationship between dietary chemical composition and the thickness of backfat of sows using Pearson's correlation analysis. And then, predictor variables; dietary protein and metabolizable energy levels were entered into simple linear regression analysis to predict the sow backfat thickness as a response variable for pregnant and lactating sow groups, and also, any correlated variables were subjected by stepwise method of multiple linear regression analysis to reveal a primary nutrient that affect the thickness of backfat. All computing for the statistical values were performed by using statistical software package (SPSS 18.0; Inc, Chicago, IL, USA). The level of statistical significance was pre-set at  $P < 0.05$ .

### **Results**

Chemical composition of pregnant and lactating sow diets. The outcome for the analyzed chemical composition of pregnant sows diets (n=84) were;  $94.43 \pm 0.01\%$  DM,  $60.89 \pm 0.04\%$  NFE,  $14.37 \pm 0.03\%$  crude protein,  $7.92 \pm 0.01\%$  ash,  $6.06 \pm 0.02\%$  crude fiber,  $5.20 \pm 0.02\%$  crude fat,  $3,399.74 \pm 2.04$  (kcal DE/kg) and  $3,346.04 \pm 1.88$  (kcal ME/kg). Likewise, chemical composition of the diet of lactating sows (n=84) were;  $94.43 \pm 0.02\%$  DM,  $56.94 \pm 0.06\%$  NFE,  $18.77 \pm 0.03\%$  crude protein,  $7.19 \pm 0.01\%$  ash,  $3.92 \pm 0.02\%$  crude fiber,  $7.74 \pm 0.04\%$  crude fat,  $3,748.57 \pm 2.10$  (kcal DE/kg) and  $3,659.93 \pm 2.04$  (kcal ME/kg) as shown in Table 1.

**Table1.** Chemical composition of pregnant and lactating sow diets from the seven pig farms observed

Chemical composition	Pregnant sow diet	Lactating sow diet
Dry matter, %	94.43 ± 0.01	94.43 ± 0.02
Nitrogen free extract, %	60.89 ± 0.04	56.94 ± 0.06
Crude protein, %	14.37 ± 0.03	18.77 ± 0.03
Ash, %	7.92 ± 0.01	7.19 ± 0.01
Crude fiber, %	6.06 ± 0.02	3.92 ± 0.02
Ether extract, %	5.20 ± 0.02	7.74 ± 0.04
Digestible energy, kcal DE/kg	3399.74 ± 2.04	3748.57 ± 2.10
Metabolizable energy, kcal ME/kg	3,346.04 ± 1.88	3,659.93 ± 2.04

#### Descriptive statistics of whole data set of backfat thickness of sows

Table 2 showed the descriptive statistics values of the whole data obtained from measuring the sow

backfat thickness of 10,401 heads from the commercial seven pig farms which found the arithmetic mean of backfat thickness of all data series was 15.52 mm.

**Table 2.** Descriptive statistics of whole data set of sow backfat thickness throughout seven pig farms observed

Descriptive statistics parameter	Observed value
Mean	15.52
Median	15.00
Mode	13.00
Standard deviation	4.57
Standard error	0.04
Sample variance	20.92
Kurtosis	2.20
Skewness	1.10
Range	38
Minimum	6
Maximum	44
Count	10,401

Consequently, the values of sow backfat thickness were accounted into eleven sow statuses and when considered the backfat thickness within each group of sow status found that mating sows had the minimum thickness of backfat was  $13.15 \pm 0.25$  mm, and found that of pregnant sows at 4, 8 and 12 weeks tended to increase by the means were  $13.96 \pm 0.08$ ,  $14.48 \pm 0.08$  and  $15.32 \pm 0.08$  mm, respectively. Moreover, the

outcome revealed that the backfat thickness of pre-farrowing sows had the maximum value was  $15.81 \pm 0.16$  mm, and when observed the groups of lactating sow during 1, 2 and 3 weeks indicated that backfat thickness tended to decrease rapidly, with the means were  $15.04 \pm 0.13$ ,  $14.05 \pm 0.15$  and  $13.76 \pm 0.17$  mm, respectively, with the number of sow in each group as detailed in Table 3.

**Table 3.** Sow backfat thickness (mm  $\pm$  SE), diet formula offered and sow status through out seven pig farms

Sow group no.	Sow status	Diet formula offered	Head	Sow backfat thickness
1	Mating Sow	Pregnant sow diet	171	$13.15 \pm 0.25$
2	Post Mating Sow	Pregnant sow diet	629	$14.01 \pm 0.14$
3	Pregnant 4 weeks Sow	Pregnant sow diet	2,001	$13.96 \pm 0.08$
4	Pregnant 8 weeks Sow	Pregnant sow diet	2,144	$14.48 \pm 0.08$
5	Pregnant 12 weeks Sow	Pregnant sow diet	2,106	$15.32 \pm 0.08$
6	Pre-Farrowing Sow	Lactating sow diet	709	$15.81 \pm 0.16$
7	Lactating 1 week Sow	Lactating sow diet	909	$15.04 \pm 0.13$
8	Lactating 2 weeks Sow	Lactating sow diet	656	$14.05 \pm 0.15$
9	Lactating 3 weeks Sow	Lactating sow diet	411	$13.76 \pm 0.17$
10	Lactating 4 weeks Sow	Lactating sow diet	177	$13.97 \pm 0.28$
11	Weaned Sow	Lactating sow diet	488	$14.15 \pm 0.16$
<b>Total</b>			<b>10,401</b>	<b><math>15.52 \pm 0.04</math></b>

#### The correlation between backfat thickness and chemical composition in sow diets

All of the data series, using Pearson's correlation calculated by considering the relationship between backfat thickness and percentage composition of nutrients in the diets of sows found that the percentage dietary moisture ( $P < 0.05$ ), fiber ( $P < 0.01$ ) and carbohydrate ( $P < 0.01$ ) were negatively correlated with backfat thickness of sows with the Pearson's correlation coefficient ( $r$ ) were  $-0.023$ ,  $-0.036$  and  $-0.057$ , respectively. In the other hand, the percentage of dry matter ( $P < 0.05$ ), crude protein ( $P < 0.01$ ), crude fat ( $P < 0.01$ ), DE ( $P < 0.01$ ), ME ( $P < 0.01$ ) were positively correlated with backfat thickness of sows with the Pearson's correlation coefficient were  $0.023$ ,  $0.036$ ,  $0.092$ ,  $0.052$  and  $0.053$ , respectively.

#### The regression analysis between chemical composition in sow diets and backfat thickness

The relationship between sow backfat thickness in millimeters with the percentage of chemical composition in sow diets found the positive correlation with statistically significant either the percentage of crude protein or metabolizable energy (ME, kcal/kg). Based on enter method of simple linear regression analysis, regression equations could be created to predict the backfat thickness (Y, mm), from the percentage of dietary crude protein (X, %) which found that the equations predict for pregnant and lactating sow diets as shown detail in Table 4.

**Table 4.** The regression equation between the percentage of crude protein and sow backfat thickness

Item	Response variable	Predictor variable	Intercept	Slope	N	R <sup>2</sup>	P-value
Pregnant sow	Backfat Thickness (Y, mm)	Dietary crude protein (X, %)	14.494	0.066	7051	0.001	0.002
Lactating sow	Backfat Thickness (Y, mm)	Dietary crude protein (X, %)	17.907	-0.115	3350	0.001	0.030

Likewise, Base on enter method of simple linear regression analysis, regression equations could be created to predict the backfat thickness (Y, mm), from

the percentage of dietary crude protein (X, %) which found that the equations predict for pregnant and lactating sow diets as shown detail in Table 5.

**Table 5.** The regression equation between metabolizable energy (ME) and sow backfat thickness

Item	Response variable	Predictor variable	Intercept	Slope	N	R <sup>2</sup>	P-value
Pregnant sow	Backfat Thickness (Y, mm)	Dietary ME (X, kcal/kg)	6.411	0.003	7051	0.007	0.000
Lactating sow	Backfat Thickness (Y, mm)	Dietary ME (X, kcal/kg)	24.540	-0.002	3350	0.002	0.002

Upon, a multiple linear regression analysis based on model fitting of stepwise method with including the diets for pregnant and lactating sow. These outcome found that the significant factor influencing change in backfat thickness was the percentage of crude fat, when other variables; the percentage of dry matter, ash, crude fiber,

crude protein, carbohydrate, digestible energy and metabolizable energy, were excluded from the regression model. And the fitting model regression equation to predict the sow backfat thickness (Y, mm), from the percentage of crude fat (X,%),was shown in table 6.

**Table 6.** The stepwise fitting model regression analysis throughout the percentage of nutrients and sow backfat thickness of whole data set

Item	Response variable	Predictor variable	Intercept	Slope	N	R <sup>2</sup>	P-value
Whole data	Backfat Thickness (Y, mm)	Dietary crude fat (X, %)	14.368	0.198	10401	0.009	0.000

### Discussion

This survey study aimed to determine the relationship between the percentages of protein and energy in diets on sow backfat thickness under rearing conditions in Thailand. We found that each farm, themselves, formulated the sow diet into two formulas with consist of pregnant sow diet and lactating sow diet as shown in Table 1, for fed to any sow statuses as shown in Table 3. The outcome for the overall analyzed chemical compositions of pregnant sows diets were;

14.37 ± 0.03 % CP and 3,346.04 ± 1.88 kcal ME/kg, while, for lactating sows were; 18.77 ± 0.03 %CP and 3,659.93 ± 2.04 kcal ME/kg, which found that levels of protein and energy in both diets, under rearing condition of commercial pig herds of Thailand were higher than that recommended by NRC (1998) reported that 12 %CP for pregnant, 18 %CP for lactating sow and 3,265 kcal ME/kg for all class, which these lead the sow backfat thickness cloud be higher than that of optimal range.

The present result of the overall sow backfat thickness found in this study was 15.52 mm (Table 2), which was higher than that of the optimal range (12 mm) so as to maximize sow productivity performance (Tvrdon, 1998; Cechova and Tvrdon, 2006; Imboonta et al., 2007), which our current fact implicitly assumes that commercial pig herds in Thailand had too high concentrations of dietary protein and energy that of reflecting poor nutritional management to optimum backfat thickness of sow. In addition, our observed correlation between backfat thickness of sows and the percentage chemical compositions of the diets showed that the percentage of dietary protein and metabolizable energy were positively correlated with backfat thickness (Pearson correlation,  $P < 0.01$ ), and these fact confirmed earlier studies of Averette et al. (2002); De Rensis et al. (2005); Dourmad et al. (1994, 1998); Everts and Dekker (1995) and Oi Dowd et al. (1997), did conclude that dietary protein and energy levels were significantly correlated with backfat thickness of sows and thereby their productivity performance. However, when we observed the determination coefficient ( $R^2$ ) values of dietary protein and energy effect of the linear regression equations either pregnant or lactating sow were very low values (Table 4 and 5), which may due to narrow diversity levels of dietary protein and energy in each farm and also their concentrations were higher than that of NRC (1998) recommended which lead to be saturated point of nutritional influence.

Moreover, the outcome of the relationship between the chemical compositions of the diets and backfat thickness based on the fitting model of stepwise multiple linear regression analysis did reveal that the percentage dietary crude fat was a key factor influencing the thickness of sow with statistical significance ( $P = 0.000$ ). This outcome revealed regression equation as a detail shown in Table 6. However, the  $R^2$  values observed of both for the simple and fitting model of regression equations were low values, which might indicating that there were many factors influence on the

variation of backfat thickness of sows and subsequent their productivity such as; sow age, body weight (Tummaruk et al., 2007; Kirkwood and Thacker, 1989), parity (Kirkwood and Thacker, 1989; Koketsu et al., 1998; Tantasuparuk et al., 2000), breeds of sow (Gourdine et al., 2006), rearing management (Koketsu and Dial, 1997), climate and humidity condition (Gourdine et al., 2006; Prunier et al., 1997; Suriyasomboon et al., 1996), especially under the variety of rearing conditions of commercial pig herds in Thailand.

In conclusion, a major nutritional factor that affects increasing or decreasing of sow backfat thickness was the dietary energy in term of crude fat in sow diet. In the future, it should work on with the control experiment studies which minimize confounding factors mentioned above to verify the relationship between crude fat sources, concentrations, and its intake to provide ranges of the optimal backfat thickness of sow to increase sow productivity efficacy.

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