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# Effect of dietary protein levels on productive performance and carcass traits of Thai native pigs from different geometric regions

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**Abstract** Southern native pigs (ST) group had significantly higher final weight ($P < 0.05$). Northern native pigs (NT) had the highest average daily gain (ADG) during the first 21 days of the rearing period ($P < 0.05$). Feed conversion ratio (FCR) and feed cost per gain (FCG) of NT and ST were lower than those of northeastern native pigs (NE) ($P < 0.05$). The lowest FCG were obtained with 12% and 14% protein diets, and the highest FCG were obtained with 18% protein diet ($P < 0.05$). For carcass traits, ST had higher slaughter weight, while NT had lower carcass weight, lower percentage of carcass, thinner backfat thickness, lower tenderloin weight, lower fat and skin weight, and lower belly weight, but had higher offal weight, higher percentage of offal and better marbling ($P < 0.05$). Dietary protein content did not affect carcass traits except for percent belly, because at 18% protein content, percent belly was lower than other groups ($P < 0.05$). For commercial production, NT could be of greater use because it had lower FCR and FCG without differing significantly in lean content. In addition, NT had higher marbling but lower backfat thickness.

**Keywords:** Thai native pigs, Average daily gain, Feed cost per gain, Carcass composition

## Introduction

In the past, Thai people preferred to eat Thai native pork. There are several breeds of Thai native pigs (TNPs), such as "Raad or Kadon" pigs in the lower northeast, "Puang" pigs in the upper northeast, "Hainan" pigs in the center, east, west, and south, and "Kwai" pigs in the north. These pig breeds were common long ago, but are now endangered or nearly extinct (Rattanaronchart, 1994). However, they were raised free-range with minimal

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feeding. Currently, Thai native pigs are not suitable for commercial pig production because they have low average daily gain (ADG), high feed conversion ratio (FCR), and poor carcass quality because they have high fat content, but low lean content compared to commercial pig breeds (Mahinchai *et al*., 2005; Na-Lampang, 2012; Falvey, 1981). Commercial pig breeds were imported and developed to achieve high productivity and meat quality for rearing in commercial pork production in Thailand (Thanapongtharm *et al*., 2016). However, Thai native pigs have the advantage of being well adapted to the hot and humid climate, requiring low-quality feed, and being resistant to foot-and-mouth disease (Falvey, 1981; Rattanaronchart, 1994). They are still raised by some groups of people or small farmers (Mahinchai *et al*., 2005; Falvey, 1981). In order to maintain and increase the value of native pigs and to obtain information on native pigs, the objective of the study was to investigate the growth performance and carcass characteristics of native pigs from three different regions of Thailand fed different protein diets.

## Materials and methods

### *Animals and feeding*

The study was conducted at a Swine Research and Development Center, Department of Livestock Development, Nakhon Ratchasima Province, Thailand. A total of 37 Thai native castrated male pigs with an average weight of 21.23 ± 6.10 kg were obtained from 15 northern native pigs (NT), 11 northeastern native pigs (NE), and 11 southern native pigs (ST). Pigs from each area were divided into 4 groups, each of which received 4 different diets for finishing pigs with protein levels of 12, 14, 16, and 18% (Table 1). Pigs in each group were randomly assigned to each protein feed. There were 8, 9, 10, and 10 pigs fed diets with 12, 14, 16, and 18% protein level, respectively. Each of these animals was housed in a single cage. All were fed *ad libitum* and had water available throughout the day.

### *Data collection*

#### Productive performance measurements

Individual pigs were weighed at the beginning, 21$^{st}$ day, 42$^{nd}$ day, 63$^{rd}$ day, and the end of rearing, and each group differed in reaching the target weight of 60 kg at different rearing times. Feed intake and the number of rearing days of each pig were recorded. Average daily gain (ADG), feed conversion ratio (FCR), average daily feed intake (ADFI), and feed cost per gain (FCG) were calculated and the formula for how they are calculated, is as follows.

ADG = (ending weight – starting weight) ÷ number of days on feed

FCR = Feed provided over time (kg) ÷ Weight gained in the same time (kg)

FCG = feed cost ÷ (ending weight – starting weight)

**Table 1**. Composition of finishing pig diets

| Ingredient | Crude protein level (% dry matter basis, DM) | | | |
|---|---|---|---|---|
| | 12 | 14 | 16 | 18 |
| Broken rice | 58.00 | 55.40 | 53.00 | 53.50 |
| Rice bran | 30.00 | 26.00 | 24.00 | 18.00 |
| Soybean meal | 8.90 | 15.50 | 15.90 | 20.40 |
| Fish meal | - | - | 4.00 | 5.00 |
| $CaHPO_4$ | 2.00 | 2.00 | 2.00 | 2.00 |
| Salt | 0.50 | 0.50 | 0.50 | 0.50 |
| Lysine | 0.10 | 0.10 | 0.10 | 0.10 |
| Premix | 0.50 | 0.50 | 0.50 | 0.50 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 |
| Price (Baht/kg) | 13.75 | 14.41 | 15.51 | 16.27 |
| Calculated Nutrient Composition (%) | | | | |
| Crude protein (CP) | 12.17 | 14.37 | 16.35 | 18.22 |
| Crude fiber (CF) | 3.58 | 3.51 | 3.88 | 3.61 |
| Ether extract (EE) | 4.21 | 3.77 | 3.85 | 3.27 |
| Total calcium (Ca) | 0.54 | 0.55 | 0.75 | 0.81 |
| Total phosphorus (P) | 0.54 | 0.54 | 0.65 | 0.66 |
| Lysine | 0.66 | 0.81 | 0.97 | 1.11 |
| Methionine | 0.28 | 0.31 | 0.35 | 0.38 |
| Metabolizable Energy (kcal/kg) | 3,282.41 | 3,251.45 | 3,215.41 | 3,119.76 |

**Carcass trait measurements**

At the end of the rearing period, the pigs with an average body weight of 60.55 ± 3.48 kg were slaughtered in the slaughter unit of the Swine Research and Development Center. After 18 hours of feed deprivation, the pigs were electrically stunned, exsanguinated, dehaired, and eviscerated. Each carcass was cut in half with an electric saw, and the weight of the hot carcass was measured. The length of the carcass was measured from the cranial edge of the first rib to the cranial tip of the aitch bone. Average back fat thickness was measured at the first rib, last rib, and last lumbar. The loin eye area (LEA) was determined by tracing on a clear plastic sheet placed on the cut surface of the longissimus muscle between the $10^{th}$ and $11^{th}$ ribs. The traced LEA was measured using a leaf area meter (LI -3100C, LI-COR Inc. Lincoln, NE, USA). Then, the carcasses were chilled in a cold room at a temperature of 0-4 ℃ for 24 hours. The marbling scores on the cut surface of the 10-11 ribs were evaluated 24 hours postmortem by an experienced person. Marbling scores were reported on a scale of 1-5 estimated from Procedures to Evaluate Market Hogs (NPPC,

1991). Then, each carcass was fabricated, and carcass composition was recorded.

### *Statistical analysis*

Data were analyzed with a general linear model using Proc GLM. Least-squares means were separated using the PDIFF option. Values of $P < 0.05$ were considered statistically significant. Statistical analysis was performed using SAS Institute Inc, Cary, NC, USA. The factorial in completely randomized design without interaction was used in this experiment. There were two treatments included groups of pig (NE, NT and ST pig) and dietary protein levels (12%, 14%, 16% and 18% dietary protein). The experimental model included terms for the pig groups and dietary protein levels as the main effects, while the interaction term, which was not significant at the 0.05 probability level, was removed from the model. In addition, age at the start of the trial was included as a covariate in the model with all performance characteristics. Slaughter weight was included as a covariate in the model with all carcass traits except marbling score, for which the covariate was not significant ($P > 0.05$).

## Results

### *Productive performance*

Growth performance of Thai native pigs from different regions fed different protein levels is shown in Table 2. The initial age was significantly different between pig groups ($P < 0.01$). It was included as a covariate in the statistical model for all traits studied in Table 2. The results showed a significant difference between pig groups in terms of final body weight ($P < 0.01$), ADG day 1-21, FCR ($P < 0.05$) and FCG ($P < 0.05$). ST had a higher final body weight than NT and NE ($P < 0.01$). NT showed higher ADG during the first 21 days of rearing, followed by ST and NE. FCR of NT and ST was significantly lower than that of NE, namely 3.18, 3.38, and 3.95. NE pigs showed higher FCG than NT and ST ($P < 0.05$), namely 58.79, 50.35, and 47.08 baht/kg, respectively. In the effect of dietary protein content, there was a significant difference ($P < 0.05$) between treatment groups only in FCG, as higher dietary protein content resulted in higher FCG, namely 57.54, 53.03, 49.03, and 48.71 baht/kg at protein content of 18%, 16%, 14%, and 12%, respectively.

**Table 2.** Productive performance of Thai native pigs from different geometric regions fed with different dietary protein levels

| Trait | Group (G)[1] | | | Treatment (T) | | | | RMSE | P value | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NT | ST | NE | 12% | 14% | 16% | 18% | | G | T |
| n | 18 | 11 | 12 | 9 | 11 | 11 | 10 | | | |
| Initial age (d) | 129.70[b] | 160.17[a] | 169.33[a] | 157.83 | 149.11 | 152.29 | 153.04 | 12.71 | <0.0001 | 0.515 |
| Body weight (kg) | | | | | | | | | | |
| Initial | 21.16 | 21.91 | 20.73 | 21.11 | 20.46 | 21.73 | 21.77 | 6.43 | 0.908 | 0.961 |
| Day 21 | 34.89 | 31.02 | 27.89 | 31.07 | 30.8 | 32.05 | 31.15 | 6.53 | 0.257 | 0.974 |
| Day 42 | 44.99 | 43.4 | 40.93 | 42.57 | 44.03 | 42.74 | 43.09 | 7.33 | 0.648 | 0.972 |
| Day 63 | 59.51 | 60.92 | 60.00 | 60.33 | 59.39 | 59.39 | 61.47 | 2.25 | 0.579 | 0.289 |
| Final | 61.42[b] | 67.33[a] | 63.18[b] | 64.93 | 63.83 | 64.17 | 62.97 | 3.46 | 0.003 | 0.677 |
| Day on feed | 69.77 | 76.38 | 85.77 | 81.41 | 75.78 | 76.56 | 75.47 | 15.61 | 0.245 | 0.839 |
| ADG[2] (kg/d) | | | | | | | | | | |
| day 1-21 | 0.65[a] | 0.43[b] | 0.34[c] | 0.47 | 0.49 | 0.49 | 0.45 | 0.09 | <0.0001 | 0.644 |
| day 1-42 | 0.57 | 0.51 | 0.48 | 0.51 | 0.56 | 0.5 | 0.51 | 0.1 | 0.425 | 0.494 |
| day 1-63 | 0.62 | 0.67 | 0.66 | 0.69 | 0.61 | 0.63 | 0.68 | 0.06 | 0.609 | 0.096 |
| FCR[3] | 3.18[b] | 3.38[b] | 3.95[a] | 3.58 | 3.45 | 3.46 | 3.51 | 0.52 | 0.034 | 0.945 |
| Weight gain (kg) | 39.13 | 40.12 | 38.99 | 40.25 | 39.46 | 38.78 | 39.15 | 5.96 | 0.889 | 0.957 |
| Feed intake (kg/d) | 1.77 | 1.79 | 1.79 | 1.75 | 1.78 | 1.78 | 1.82 | 0.16 | 0.961 | 0.799 |
| FCG[4] (baht/kg) | 47.08[b] | 50.35[b] | 58.79[a] | 48.71[b] | 49.03[b] | 53.03[ab] | 57.54[a] | 7.45 | 0.024 | 0.040 |

[1] NT = Thai native pigs from northern region, ST = Thai native pigs from southern region, NE = Thai native pigs from northeastern region.
[2] ADG = average daily gain. [3] FCR = feed conversion ratio. [4] FCG = feed cost per gain.

## *Carcass characteristics*

Carcass characteristics of Thai native pigs from different geometric regions fed different protein levels are shown in Table 3. ST had higher slaughter weight than NT and NE (P<0.01). Because slaughter weight was significantly different among pig groups, it was included as a covariate in the statistical model for all traits studied in Table 3, except for marbling score. The pig groups differed significantly in body composition as NT had

higher offal weight and percentage of offal weight ($P < 0.05$), while ST and NE had higher hot and cold carcass weight and percentage of hot and cold carcass weight ($P < 0.05$). ST and NE showed greater backfat thickness, while they showed lower marbling score than NT ($P < 0.05$). There were no significant differences between groups of pigs in the loin eye area ($P > 0.05$). In carcass composition, NE showed higher tenderloin weight than NT ($P < 0.05$), while tenderloin weight of ST was not significantly different from the other groups ($P > 0.05$). Lean weight and bone weight were not significantly different among the pig groups, while ST and NE had higher fat + skin weight, and belly weight than NT ($P < 0.05$). Regarding the effect of dietary protein, there was a trend that carcasses were longer when dietary protein was higher: 77.79, 77.34, 75.56, and 73.48 cm at 18%, 16%, 14%, and 12% protein, respectively. The lower protein content in the diet resulted in a higher percentage of belly as 12%, 14%, and 16% protein had a higher percentage of belly than 18% protein ($P < 0.05$).

**Table 3.** Carcass traits of Thai native pigs from different geometric regions fed with different dietary protein levels

| Trait | Group (G)[1] | | | Treatment (T) | | | | RMSE | P value | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NT | ST | NE | 12% | 14% | 16% | 18% | | G | T |
| n | 15 | 11 | 11 | 8 | 9 | 10 | 10 | | | |
| Slaughter weight (kg) | 62.06$^{b}$ | 67.43$^{a}$ | 63.06$^{b}$ | 64.87 | 64.23 | 64.47 | 63.17 | 3.71 | 0.008 | 0.785 |
| Body composition (kg) | | | | | | | | | | |
| Offal | 9.66$^{a}$ | 7.95$^{b}$ | 7.53$^{b}$ | 8.93 | 8.24 | 8.30 | 8.06 | 1.34 | 0.012 | 0.592 |
| Head | 4.19 | 4.14 | 4.16 | 3.99 | 4.19 | 4.24 | 4.24 | 0.47 | 0.982 | 0.704 |
| Hot carcass | 46.12$^{b}$ | 51.81$^{a}$ | 50.17$^{a}$ | 48.84 | 49.04 | 49.34 | 50.24 | 3.68 | 0.035 | 0.857 |
| Cold carcass | 43.79$^{b}$ | 49.46$^{a}$ | 47.85$^{a}$ | 46.69 | 46.81 | 46.96 | 47.67 | 2.99 | 0.008 | 0.899 |
| Body composition (%)[2] | | | | | | | | | | |
| Offal | 15.30$^{a}$ | 12.48$^{b}$ | 11.80$^{b}$ | 14.09 | 12.87 | 13.08 | 12.73 | 2.22 | 0.012 | 0.611 |
| Head | 6.54 | 6.44 | 6.46 | 6.19 | 6.56 | 6.59 | 6.58 | 0.75 | 0.977 | 0.664 |
| Hot carcass | 71.61$^{b}$ | 80.98$^{a}$ | 78.62$^{a}$ | 76.04 | 76.88 | 77.03 | 78.33 | 5.65 | 0.021 | 0.865 |
| Cold carcass | 68.17$^{b}$ | 77.42$^{a}$ | 74.99$^{a}$ | 72.80 | 73.38 | 73.56 | 74.36 | 4.78 | 0.007 | 0.924 |
| Carcass length (cm) | 76.98 | 76.89 | 74.25 | 73.48 | 75.56 | 77.34 | 77.79 | 3.72 | 0.169 | 0.093 |
| Back fat thickness (cm) | 1.39$^{b}$ | 1.71$^{a}$ | 1.66$^{a}$ | 1.72 | 1.64 | 1.55 | 1.48 | 0.24 | 0.049 | 0.192 |
| Loin eye area ($cm^2$) | 14.76 | 15.21 | 16.06 | 14.51 | 14.98 | 16.36 | 15.53 | 2.34 | 0.471 | 0.392 |
| Marbling score[3] | 1.28$^{a}$ | 0.99$^{b}$ | 1.00$^{b}$ | 0.988 | 1.112 | 1.15 | 1.11 | 0.30 | 0.040 | 0.701 |
| Carcass composition (kg) | | | | | | | | | | |
| Loin | 1.64 | 1.69 | 1.69 | 1.55 | 1.72 | 1.73 | 1.69 | 0.31 | 0.942 | 0.639 |
| Tenderloin | 0.40$^{b}$ | 0.48$^{ab}$ | 0.53$^{a}$ | 0.44 | 0.46 | 0.50 | 0.48 | 0.07 | 0.008 | 0.381 |
| Lean[4] | 12.68 | 13.62 | 13.70 | 12.77 | 12.96 | 13.70 | 13.90 | 1.85 | 0.538 | 0.513 |
| Bone | 6.24 | 6.97 | 6.64 | 6.25 | 6.48 | 6.84 | 6.91 | 0.83 | 0.336 | 0.337 |
| Fat+skin | 13.95$^{b}$ | 15.98$^{a}$ | 16.04$^{a}$ | 15.53 | 15.64 | 15.03 | 15.11 | 1.49 | 0.024 | 0.777 |
| Belly | 8.76$^{b}$ | 9.69$^{a}$ | 9.53$^{a}$ | 9.44 | 9.52 | 9.37 | 8.98 | 0.61 | 0.030 | 0.253 |

**Table 3.** (Con.)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Carcass composition (%)[5] | | | | | | | | | | |
| Loin | 3.75 | 3.37 | 3.52 | 3.10 | 3.65 | 3.67 | 3.57 | 0.61 | 0.569 | 0.611 |
| Tender loin | 0.92 | 0.98 | 1.09 | 0.93 | 0.97 | 1.07 | 1.02 | 0.16 | 0.058 | 0.302 |
| Lean | 28.96 | 27.39 | 28.62 | 27.27 | 27.63 | 29.17 | 29.27 | 3.33 | 0.653 | 0.483 |
| Bone | 14.06 | 13.85 | 13.94 | 13.26 | 13.81 | 14.51 | 14.22 | 1.48 | 0.971 | 0.345 |
| Fat+skin | 32.14 | 32.25 | 33.58 | 33.73 | 33.52 | 32.07 | 31.29 | 3.95 | 0.649 | 0.517 |
| Belly | 20.11 | 19.42 | 19.98 | 20.37[a] | 20.44[a] | 20.00[a] | 18.53[b] | 1.51 | 0.660 | 0.037 |

[1] NT = Thai native pigs from northern region, ST = Thai native pigs from southern region, NE = Thai native pigs from northeastern region. [2]Percentage of each body composition was calculated by taking (weight of each carcass composition/slaughter weight) *100. [3]Marbling on the 10th and 11st ribs marbling scores were reported on a 1–5 scale estimated in the Procedures to Evaluate Market Hogs (NPPC, 1991).[4]Lean was calculated from tenderloin, loin, boston butt, picnic shoulder, and ham.[5]Percentage of each carcass composition was calculated by taking (weight of each carcass composition/cold carcass weight) *100.

## Discussion

### *Productive performance*

Vasupen *et al*. (2008) reported that Thai pigs from the northeastern region called Kadon had body weights of 19, 24, 31, and 65 kg in male pigs at 120, 150, 180, and 365 days of age, respectively. In this study, the initial body weights of TNPs at 129.7, 160.2, and 169.3 days of age were 21.16, 21.91, and 20.73 kg for NT, ST, and NE, respectively. NT Pigs in this study were similar in weight to the Kadon pigs from the Vasupen *et al.* (2008), while ST and NE were lower in weight compared to the Kadon pigs at the same age. Vasupen *et al.* (2008) reported that male Kadon pigs with an initial weight of 8.4 kg after 45 days of rearing, fed *ad libitum* with a 16% protein diet, reached a final body weight of 21.20 kg with an ADG of 285.6 g/d and an FCR of 2.74. Because the studied pigs were small animals that could be younger compared to our study, their ADG was lower than in our study. However, they had a better FCR of 2.74 than those in our study with FCR values of 3.18-3.95. A possible explanation could be that pigs at a younger age have better feed conversion than older ones. As mentioned by Patience *et al*. (2015), feed conversion is a function of body weight, so the pig is less efficient in converting feed into body weight gain as weight increases. Mahinchai *et al*. (2005) reported that TNPs from the northern region had better growth performance after breeding selection, with first and second-generation pigs having better ADG, FCR, backfat thickness, and loin eye area than their parents. Their ADG was 347.26, 327.66, and 431.54 g/day, FCR was 3.39, 2.90, and 2.76, backfat thickness was 2.39, 2.34, and 2.36 cm, and loin eye area values were 19.22, 22.91, and 24.41 $cm^2$ for the parents, first, and second generations, respectively.

Na-Lampang (2012) reported that TNP from northeastern Thailand aged 8-31 weeks fed rice bran had an average ADG of 0.31 and 0.37 kg/day for males and females, respectively. They also reported that the weight of TNPs at 15, 20, 25, and 31 weeks of age was 21.53, 32.13, 43.23, and 55.86 kg for males and 23.82, 35.09, 51.91, and 61.44 kg for females, respectively. Both the weight and ADG of the pigs from their study were lower than those in our study, which may be due to the difference in diet. It can be concluded that TNPs fed with high quality feed showed better growth performance than pigs fed with natural feed or low-quality feed that did not meet their requirements. However, in our study, the protein content of the feed did not show any effect on the growth performance of TNPs. Therefore, the protein content of 12% might be sufficient for feeding TNP at a reasonable cost because it has a lower FCG value.

***Carcass characteristics***

Carcass characteristics of ST and NE looked similar and differed from NT. ST and NE had both a higher weight and a higher proportion of hot and cold carcasses, but a lower proportion of offal than NT. The higher carcass weight could be related to the higher tenderloin weight of ST and NE compared to NT. The lean and bone weights of ST and NE were also higher than those of NT, but not enough to show a significant difference. Greater back fat thickness resulted in higher fat + skin and belly weight of ST and NE than NT. Knecht and Duzinski (2016) showed a significant positive correlation between back fat thickness and skin with subcutaneous fat ($r = 0.81$), but a significant negative correlation with muscle ($r = -0.74$) and bone mass ($r = -0.44$). Normally, back fat thickness had a positive correlation with marbling score or intramuscular fat content (Knecht and Duzinski, 2016). However, in our study, the higher back fat thickness ST and NE showed lower marbling score than NT. The possible explanation may be that the genes controlling fat deposition in subcutaneous fat are different from the genes controlling fat deposition in muscle (Zhang *et al.*, 2022). Therefore, further investigation of the genes related to intramuscular fat synthesis in Thai native pigs from different regions of Thailand could be beneficial for the selection of quality pigs. Regarding the effects of dietary protein content on carcass characteristics of Thai native pigs, this study found a slight increase in carcass, lean, and bone mass and increased carcass length with a slight decrease in fat mass, belly, and thinner back fat thickness in higher protein content diet. Therefore, the 12% protein diet may

be adequate for feeding native Thai pigs without negative effects on carcass quality.

In conclusion, Thai native pigs from different geometric regions had similar growth rate during the 63-day rearing period. However, NT pigs had lower FCR than ST and NE pigs. There were significant differences between pig groups for some carcass traits. The protein content of the diet had little effect on the performance and carcass traits of the pigs in this study. The results suggest that NT pigs may have a higher profit for commercial production due to lower FCR and FCG. Although they had lower carcass weight, the difference could be due to higher fat content rather than higher lean content because ST and NE had higher fat content, but there was no significant difference in lean content among the three groups of pigs.

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