

Effect of Complete Feed Feeding Level and Morning Glory on Growing Pig Performance

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Abstract

A total of 60 castrated male pigs (Yorkshire x Duroc, initially 17.36 kg) were used in a 42-day trial to evaluate the effect of complete feed feeding level and morning glory on growth performance of growing pigs. Pigs were allotted to pens and randomly assigned to three dietary treatments: A) complete feed *ad libitum*; B) complete feed fed at 75% of intake of treatment A, and C) treatment B with *ad libitum* availability of morning glory. The design was a completely randomized design (CRD) with five pens (replications) of each treatment with four pigs per pen. Average daily feed intake (dry matter basis) was higher ($P < 0.001$) for pigs fed treatment A (1420 g/d) compared to treatment B (1048 g/d) as expected, with treatment C intermediate (1178 g/d; 1048 g/d complete feed + 130 g/d morning glory). Average daily weight gain of pigs fed *ad libitum* was greater ($P < 0.001$) than pigs restricted fed with pigs which provide morning glory intermediate (871, 674 and 714 g, respectively). Feed efficiency improved ($P < 0.024$) for pigs fed the restricted feed level compared to pigs fed complete feed *ad libitum* or pigs restricted fed but provided morning glory (1.63, 1.56 and 1.65, respectively). For economics, feeding complete feed *ad libitum* improved ($P < 0.001$) income over feed cost compared to restricted feeding or providing morning glory (USD 41.48, 33.42, and 33.89/pig, respectively). In conclusion, feeding growing pigs a complete diet *ad libitum* resulted in the greatest growth rate and profitability. Offering morning glory (*Ipomoea aquatica*) to pigs fed a restricted level of complete feed did improve final body weight, but the extra cost of feeding morning glory offset this advantage resulting in similar profitability on an income over feed cost basis.

Keywords

Complete Feed, Feed Restriction, Growing Pig, Growth Performance, Morning Glory

1. Introduction

In countries with a lack of a sufficient domestic commercial swine feed and low utilization of alternative domestic feed resources, a higher cost of production is found [1]. Since feed cost is the most expensive input in commercial pig production [2], pig diet formulation and feeding strategies are not only important for animal performance, but also to maximize profitability [3]. Cambodia imported an increasingly amount of commercial feed from 60,000 tons in 2009 to 452,671 tons in 2013 to fulfill the requirement of the growing feed need [4].

A restricted feeding program where pigs are fed less than *ad libitum* intake will reduce overall growth performance and bone growth and mineralization in growing pigs [5]. While medium and larger producers of swine often feed complete rations *ad libitum*, due to the high cost of purchased feed, small scale producers do not. In order to have more economical rations for swine, small farms in Cambodia often feed rice bran, kitchen waste, or other locally available feed ingredients [6]. For instance, water morning glory or spinach (*Ipomoea aquatica*), which is marsh plant, is readily grown in Cambodia and other South-East Asian regions allowing it to be widely used for feeding pigs [7]. However, morning glory is a fibrous plant that offers little nutritional value to swine since it is fed fresh after harvest, thus having low dry matter content.

2. Material and Methods

2.1. The Site of Study and Climate Condition

The experiment was conducted at local pig barn facility in the district of S'ang, Kandal province, approximately 21 km from Phnom Penh, Cambodia. The regional climate during the study was in rainy season (May to October) with the average daily temperature of 29°C with 81% humidity. Daily temperature and humidity were measured inside the pig barn. Minimum and maximum temperatures were 25°C and 37°C, respectively, and relative humidity was ranged from 74% to 91% during the experiment.

2.2. Pigs and Experimental Design

A total of 60 castrate male pigs (Yorkshire x Duroc) were purchased from a large commercial farm with an initial body weight of 17.36 kg was used in a 42-day trial. Pigs were allotted to pens and randomly assigned to three dietary treatments: A) complete feed fed *ad libitum*; B) complete feed fed at 75% of intake of treatment A, and C) complete feed fed at 75% of intake of treatment A with *ad libitum* availability of morning glory. The 75% of intake level was chosen as

this was a routine amount given by small swine producers in Cambodia. The experiment was a completely randomized design (CRD) with five pens (replications) of each treatment and four pigs per pen. Pigs were put into individual pens (2 × 3 m) with concrete floor. A nipple drinker was available in each pen to provide *ad libitum* access to fresh water. Pigs had been adapted to the barn and environment for 7 days prior to the start of the experiment which was conducted from May 9 to June 22, 2018.

2.3. Diets and Feeding

Complete feed was formulated to two dietary phases (**Table 1**) based on the nutrient requirements of pigs from 17 to 30 kg and 30 to 50 kg body weight, respectively. For the two phases, the complete feeds had a crude protein content of 19% and 16% with metabolizable energy of 3350 and 3300 kcal/kg, respectively (manufactured by CP Cambodia co. Ltd). The complete feed was in pellet form. Fresh morning glory was harvested and purchased from a local supplier. Morning glory (*Ipomoea aquatica*) was cleaned with fresh water and chopped into a small piece prior to provide to pigs daily. In treatment A, complete feed was offered

Table 1. Composition of complete diets used in the experiment (as-fed basis)^a.

| Items, % | Diet 1 | Diet 2 |
|-----------------------------|--------|--------|
| Corn | 40.00 | 40.00 |
| Cassava | - | 11.00 |
| Wheat | 15.00 | - |
| Full Fat Soy | 6.50 | - |
| Soybean meal | 21.00 | 27.00 |
| Rice bran full fat | - | 15.00 |
| Palm Oil | 4.00 | 4.00 |
| Milk Product | 5.00 | - |
| Other ^b | 8.40 | 2.90 |
| Vitamin Premix | 0.05 | 0.04 |
| Mineral Premix | 0.06 | 0.06 |
| Calculated Nutrition | | |
| ME, kcal/kg | 3350 | 3300 |
| Crude protein, % | 19.00 | 16.00 |
| Fat, % | 4.00 | 4.00 |
| Crude fiber, % | 4.00 | 4.00 |
| Calcium, % | 0.70 | 0.66 |
| Phosphorus, % | 0.38 | 0.32 |
| SID Lysine, % | 1.25 | 1.00 |

^aDiet 1 fed from approximately 17 to 30 kg body weight and diet 2 from approximately 30 to 50 kg body weight. Diets were fed in pellet form and manufactured by CP Cambodia Co. Ltd. ^bMinerals, synthetic amino acids, and other proprietary ingredients.

ad libitum to pigs and the amount of daily feed consumption of pigs in this treatment was measured to set the feeding level of complete feed for treatments B and C. Actual feed intake achieved was 74% for both treatments B and C compared to pigs fed at ad libitum. Pigs were fed three times a day at 07:00, 12:00 and 18:00. For economics, the complete diet cost for phase 1 complete feed was USD 0.60/kg, phase 2 complete feed was USD 0.50/kg and morning glory was USD 0.06/kg fresh. Also, a value of USD 2.125/kg was used to calculate the revenue value of weight gain during the experiment.

2.4. Sample and Data Collection

Any residual feed not consumed by each pen of pigs was weighed back and recorded daily. Morning glory and complete feed samples were collected, sent to Chemical Analysis Laboratory, Royal University of Agriculture, Phnom Penh, and analyzed for dry matter in order to calculate feed intake on a dry matter basis. Pigs were individually weighed on d 0, 7, 14, 21, 28 and 42 day of the study to calculate ADG, ADFI and feed efficiency (F/G).

2.5. Analytical Analysis

Complete feed and fresh morning glory samples were collected and analyzed for dry matter according to the official method [8] (Code 934.01). Ash was ignited in a muffle furnace at 600°C during 2 h according to the description of [8] (Code 942.05). Crude protein was determined by Leco FP-528 (LECO Corporation, ISO-9001:2008, USA, 2014), and estimated a calculation of crude protein factor ($N \times 6.25$). Ether Extract (EE) was determined by using ST243 Soxtec™ Extraction Unit (Foss Analytical Co., Ltd, China, 2014). Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), and Crude Fiber were determined by ANKOM 200i, approved procedure by AOCS (ANKOM Technology, USA).

2.6. Statistical Analysis

All data were entered and prepared to statistical analysis in Microsoft excel 2013. Statistical analysis was conducted by using the software of Statistical Package for the Social Sciences (SPSS) version 18.0. The analytical procedure was processed with one-way of analysis of variance (ANOVA-test) to compare the variable means, and determined the statistical significant different of means at the probability level ($P < 0.05$). Duncan test was used to evaluate the difference between means.

3. Results

The chemical composition of morning glory (*Ipomoea aquatica*) showed low DM (10.38%) and EE (2.43%) concentrations but higher CP (25.35%) on a DM basis (Table 2). The ash, crude fiber, ADF, and NDF concentrations were relatively high as expected. The DM content of Diet 1 was 87.58% while than Diet 2 was 89.64%. The CP analysis of complete feed for Diet 1 and Diet 2 were similar

Table 2. Chemical composition of complete feed and morning glory used for the experiment (% as DM)^a.

| Items | Diet 1 | Diet 2 | Morning glory |
|-------------------------|--------|--------|---------------|
| Dry matter | 87.58 | 89.64 | 10.38 |
| Crude protein | 19.64 | 16.81 | 25.35 |
| Crude fiber | 3.61 | 2.57 | 14.94 |
| Ether extract | 6.85 | 6.48 | 2.43 |
| Ash | 5.08 | 5.29 | 12.58 |
| Acid detergent fiber | 4.70 | 3.85 | 24.76 |
| Neutral detergent fiber | 9.05 | 7.82 | 26.17 |

^aDiet 1 fed from approximately 17 to 30 kg body weight and diet 2 from approximately 30 to 50 kg body weight.

to calculated values. The ether extract of both diets were higher than expected, but the crude fiber was lower.

Pig growth performance during phase 1 (d 0 to 21), body weight, ADG, and ADFI were greater ($P < 0.001$) for pigs fed *ad libitum* compared to pigs on both other treatment diets (Table 3). Also, pigs fed the restricted level of complete diet with morning glory had improved body weight, ADG, and ADFI compared to pigs fed on the restricted diet. For feed efficiency, pigs fed the restricted level of complete diet had improved ($P < 0.024$) F/G compared to both other treatments.

For phase 2 (d 21 to 42), ADG was improved ($P < 0.001$) for pigs fed *ad libitum* compared to pigs fed both other treatments. Pigs fed *ad libitum* had greater ($P < 0.001$) ADFI than pigs fed both other treatments, while those fed the restricted complete diet with morning glory had increased ($P < 0.001$) feed intake compared to those only receiving the restricted diet. There was no significant ($P > 0.063$) difference in F/G between treatments.

For the overall study (d 0 to 42), ADG and final body weight were greater ($P < 0.001$) for pigs fed *ad libitum* compared to both other treatments, while restricted fed pigs provided with morning glory had greater ($P < 0.001$) ADG and body weight than pigs fed the restricted diet without morning glory. For ADFI, pigs fed *ad libitum* had increased ($P < 0.001$) intake compared to both other treatments with pigs fed the restricted complete diet with morning glory being intermediate. Feed efficiency improved ($P < 0.024$) for restricted fed pigs compared both other treatments. For economics, feeding pigs the complete feed *ad libitum* increased ($P < 0.001$) feed cost per pig and gain value compared with the other two treatments with pigs fed the restricted diet with morning glory intermediate for both measurements. For income over feed cost, pigs fed the complete feed *ad libitum* had increased ($P < 0.001$) return compared to restrict feeding or restricted feeding with morning glory.

4. Discussion

The DM content of morning glory was an agreement with previous results [9]

Table 3. Effect of complete feed feeding level and morning glory (*Ipomoea aquatica*) on growing pig performance^d.

| Items | Diets Fed | | | SEM | P< |
|---------------------------|--------------------|-----------------------|---|-------|-------|
| | <i>ad libitum</i> | 75% <i>ad libitum</i> | 75% <i>ad libitum</i> +Morning glory | | |
| Body weight, kg | | | | | |
| D 0 | 17.35 | 17.36 | 17.37 | 0.011 | 0.755 |
| D 21 | 33.13 ^a | 29.50 ^c | 30.40 ^b | 0.424 | 0.001 |
| D 42 | 53.92 ^a | 45.66 ^c | 47.38 ^b | 0.972 | 0.001 |
| Day 0 to 21 | | | | | |
| ADG, g | 751 ^a | 578 ^c | 620 ^b | 20.29 | 0.001 |
| ADFI, g | 1,105 ^a | 806 ^c | 922 ^b | 33.42 | 0.001 |
| F/G | 1.47 ^a | 1.40 ^b | 1.49 ^a | 0.015 | 0.024 |
| Day 21 to 42 | | | | | |
| ADG, g | 990 ^a | 770 ^b | 809 ^b | 26.99 | 0.001 |
| ADFI, g | 1734 ^a | 1291 ^c | 1434 ^b | 54.17 | 0.001 |
| F/G | 1.75 | 1.68 | 1.77 | 0.017 | 0.063 |
| Day 0 to 42 | | | | | |
| ADG, g | 871 ^a | 674 ^c | 714 ^b | 23.19 | 0.001 |
| ADFI, g | 1420 ^a | 1048 ^c | 1178 ^b | 43.03 | 0.001 |
| F/G | 1.63 ^a | 1.56 ^b | 1.65 ^a | 0.015 | 0.024 |
| Economics, USD/pig | | | | | |
| Feed cost ^e | 36.21 ^a | 26.72 ^c | 29.87 ^b | 1.09 | 0.001 |
| Gain value ^f | 77.70 ^a | 60.14 ^c | 63.76 ^b | 2.07 | 0.001 |
| IOFC ^g | 41.49 ^a | 33.42 ^b | 33.89 ^b | 1.03 | 0.001 |

^{a,b,c}Different superscripts are significantly different, $P < 0.05$. ^d A total of 60 pigs (initially 17.36 kg/body weight) was used in a 42 days studying with 4 pigs per pen and 5 pens per treatment. ^eAssuming in complete feed phase 1 diet (d 0 to 21) = \$0.60/kg; complete feed phase 2 diet (d 21 to 42) = \$0.50/kg, and morning glory \$0.06/kg fresh. ^fAssuming a pig price of \$2.125/kg for body weight gain from d 0 to 42). ^gIncome over feed cost (IOFC) = gain value – feed cost.

[10] [11], which showed a range from 9.1% to 11.2%, respectively. The CP content of morning glory in the present study was similar to other published values [9] [11] [12], ranging from 18.8% to 25.6%. Moreover, the ash content was 12.58%, which agreed with data from [12]; but being lower than results of [9]. Likewise, the crude fiber content was 14.94%, which showed lower value than 22.80% CF result reported by [9]. Ether extract, ADF, and NDF contents were 2.43%, 24.76% and 26.17% which were lower than published by [12].

Due to the higher cost of complete feed, small swine producers that do purchase this type of feed often do not offer it *ad libitum*. As expected in our study, pigs fed at 75% *ad libitum* had reduced growth rate than pigs fed *ad libitum*. This finding is in agreement with [5] [13] [14]. According to [5], when pigs were

fed to 70% of *ad libitum* feed intake, pigs grew 41% slower, meanwhile, in our study pigs that consumed at 75% *ad libitum* grew 23% slower and only 18% less when also offered morning glory. Lovatto [14] reported that when pigs are fed a restricted level of feed intake, they had lower protein and lipid gain which would support the lower body weight gain reported in our study. Weremko [5] reported that young pigs subjected to short-term deficiency of protein and energy intake for 28 days were able to recover and even surpass the parameters of bone mineralization compared with adequately fed pigs during those same 28 days when subsequently placed on nutrient adequate diets for approximately 50 days. When restricting the amount of feed per day to growing pigs, [15] reported that pigs offered the feed 6 vs. 2 times per day had improved ADG and feed efficiency. This is an important finding in this area of research to show how providing the same level of daily nutrients multiple times per day can potentially improve nutrient utilization and have less feed wastage compared to providing larger, less frequent meals. In the current study, pigs were offered feed three times per day.

Morning glory is a forage that is readily grown in many areas in Asia and is used for human food and as a feedstuff for livestock. As a typical forage, it is low in dry matter and fat, while high in fiber. Although not an ideal feedstuff for monogastrics compared to ruminant animals, it can be harvested daily and offered fresh to swine. In our study, the pigs fed a restricted level of complete feed did consume morning glory when it was chopped and offered *ad libitum* resulting in a significantly increased daily feed intake over the 42-day study. Chhay Ty [7] pigs fed morning glory or cassava leaves mixed with rice bran and reported pigs consumed greater amounts of mixed feed containing morning glory. This data along with the present study shows that the palatability of morning glory for pigs is acceptable and does not decrease their daily feed intake.

It should be noted that of the chopped morning glory offered pigs in our study, it was visually observed that more leaves and less stems were consumed daily. Samkol [16] reported that morning glory leaves contained a DM content of ~10% and also a higher crude protein concentration (35.1% DM basis) compared to the stem which had lower CP concentration (20.5% DM basis). This may explain why pigs offered the morning glory had intermediate performance compared to the other two treatments. While morning glory is lower in energy content than complete feed, pigs did utilize enough of the nutrients consumed to improve body weight compared to pigs not offered morning glory.

Economic evaluations have not been conducted in previous research evaluating feed restriction or feeding morning glory. While feed cost per pig increases with feeding complete feed *ad libitum*, the value of the extra body weight gain also increases resulting in the highest margin over feed cost, or a measure of net profitability. While pigs offered morning glory had increased revenue compared to those fed the restricted feeding level alone, the added feed cost of morning glory offset this advantage and resulted in not being more profitable. Thus, a swine producer must purchase morning glory at a lower cost or harvest it on their own land to justify its use in growing swine diets.

5. Conclusion

Feeding growing pigs a complete diet *ad libitum* resulted in the greatest growth rate and profitability. However, feeding a restriction of daily feed intake at 75% can improve feed efficiency compared to *ad libitum* fed pigs. Finally, offering morning glory (*Ipomoea aquatica*) to pigs fed a restricted level of complete feed did improve final body weight, but the extra cost of feeding morning glory offset this advantage resulting in similar profitability on an income over feed cost basis.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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