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Effects of Dietary Protein Levels on Growth Performance and Feed Intake in Native Moo Lath Lao Pigs

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Abstract: Three growth experiments were conducted to determine practically applicable levels of Crude Protein (CP) for weaner (5.04±0.34 kg Body Weight; BW), grower (20.2±0.32 kg BW) and finisher (39.9±1.80 BW) native Moo Lath Lao pigs fed diets based on rice bran, maize and soybean meal without supplementation of synthetic amino acids. Each experiment used 30 individually penned pigs with 6 pigs per treatment. The dietary CP content (per kg DM) was 139, 161, 181, 203 and 222 g for weaner pigs, 111, 132, 148, 168 and 192 g for grower pigs and 89, 111, 132, 148 and 168 g for finisher pigs. Pigs were randomly allocated to one of five experimental dietary treatments according to a completely randomized design. Feed and water were offered *ad libitum*. All experiments were carried out under the same conditions and according to the same procedure. The results showed that final BW, average daily gain, feed intake and feed conversion ratio did not improve above a dietary CP level (per kg DM) of 181 g for weaner pigs, 132 g for grower pigs and 111 g for finisher pigs. These levels of dietary CP content are lower compared with NRC recommendation for growing pigs of the same initial BW. This study has given a first indication of realistic target levels for CP in the diet for native Moo Lath pigs at different stages of growth. However, further studies are needed to establish more precise protein and amino acid requirements for native Lao pigs.

Key words: Moo Lath pigs, protein level, growth performance, feed intake, daily gain, feed conversion ratio

INTRODUCTION

Around 90% of smallholder pig farmers in Lao PDR keep native Lao pigs (Phengsavanh *et al*., 2011). There are four native breeds including Moo Hmong, Moo Lath, Moo Chith and Moo Deng, kept by farmers in Lao PDR (Keonouchanh *et al*., 2008). Of these four breeds, Moo Lath is more commonly kept by smallholder pig farmers than the other breeds. The Moo Lath pigs are characterized by a low body weight, a slow growth rate and high capacity to deposit fat (Phengsavanh *et al*., 2011). The growth rate of these pigs in smallholder production systems is around 100 g day^{-1} (Phengsavanh *et al*., 2010), mainly due to poor feeding but when fed a more balanced diet they can grow up to 500 g day^{-1} (Keonouchanh *et al*., 2008). However, to correctly formulate the nutrient content of the feed, knowledge of the nutrient requirement of pigs at different stages growth or stages of production is required.

Protein is an expensive part of the diet and often one of the first limiting factors for high performance of pigs in smallholder systems in Lao PDR (Phengsavanh *et al*., 2010; Chittavong *et al*., 2012). Moreover, it is important to avoid excess protein in the diet, since this will be counterproductive for growth and feeding efficiency (Hansen and Lewis, 1993; Barea *et al*., 2006). Therefore, it is of great interest and practical relevance to establish suitable levels of Crude Protein (CP) in the diet for native Lao pigs. To the knowledge, no information is available on the nutrient requirements of native breeds used in Lao PDR.

At present, diet formulation is based on nutrient requirements established for exotic breeds from sources such as the National Research Council (NRC, 1998, 2012), where pigs are kept and raised under quite different conditions as compared to pigs in Lao PDR. However, based on the present knowledge of the performance traits of native Lao pigs such as the Moo Lath, researchers hypothesize that their CP requirements are lower than those of exotic breeds used in western countries.

This study aimed at providing a first indication on the dietary CP requirements of Moo Lath pigs at different

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stages of growth using feed intake, average daily gain and feed conversion ratio as performance response criteria.

MATERIALS AND METHODS

General: Three experiments were carried through during the months March to September 2011 at the Livestock Research Center of the National Agriculture and Forestry Research Institute (NAFRI), Vientiane, Lao PDR.

Experimental diets: The diets used in all experiments were composed of rice bran, maize and soybean meal as the major components with supplementation of soybean oil to make the diets iso-energetic. The chemical composition of ingredients is shown in Table 1. All diets were supplemented with a mineral-vitamin premix and salt (NaCl).

Experiment 1: The diets were formulated to contain 14, 16, 18, 20 and 22% CP in Dry Matter (DM) (Table 2). All diets were formulated to contain an average of 19.7 (±0.23) MJ Gross Energy (GE) per kg DM.

Experiment 2: The diets were formulated to contain 11, 13, 15, 17 and 19% in DM (Table 3). All diets were formulated to contain an average of 19.3 (±0.36) MJ GE/kg DM.

Experiment 3: The diets were formulated to contain 9, 11, 13, 15 and 17% CP in DM (Table 4). All diets were formulated to contain an average of 19.2 (±0.33) MJ ME/kg DM.

Animals: The Moo Lath pigs used in the experiments were purchased from upland villages in the Vientiane province of Lao PDR. At arrival, pigs were treated for internal parasites, vaccinated against Foot and Mouth Disease (FMD) and Classical Swine Fever (CSF). They were kept in quarantine pens for 1 week and pigs with suspected health problems or noticeable lower growth rates were identified.

Experiment 1: A total of 30 healthy female Moo Lath pigs with an initial Body Weight (BW) of 5.0 (±0.34) kg and of the same age (around 3 months old) were used in the experiment. They were fed experimental diet for 63 days, from 29 March to 30 May, 2011.

Experiment 2: A total of 30 healthy female Moo Lath pigs with an initial BW of 20.2 (±0.32) kg and of the same age (around 7 months) were used in the experiment. They were fed experimental diet for 47 days from 17 June to 9 July, 2011.

Table 1: Ingredient chemical composition (g/kg DM), essential amino acids (g/kg DM) and content of metabolizable energy (ME, MJ/kg DM)

Composition	Soybean meal	Maize	Rice bran
Dry matter	927.0	931.0	892.0
Chemical composition			
Ash	55.0	16.0	104.0
Crude Protein	426.0	109.0	79.0
CF	86.0	18.0	268.0
NDF	125.0	102.0	545.0
ADF	92.0	31.0	386.0
Fat	197.0	58.0	68.0
Starch	10.0	685.0	199.0
Essential amino acids			
Arginine	25.3	4.2	3.4
Histidine	7.9	2.2	1.1
Isoleucine	17.8	3.3	2.1
Leucine	29.1	12.2	4.1
Lysine	30.7	3.5	2.9
Methionine	6.0	2.6	1.1
Phenylalanine	16.2	3.9	2.2
Threonine	14.6	3.4	2.2
Tryptophan	4.7	0.7	1.2
Valine	16.6	4.5	3.0
ME[1]	15.1	16.2	6.3

[1]Calculated values for growing pigs from analyzed chemical composition according to INRA (www.evapig.com, Version 1.3.0.2)

Table 2: Ingredient composition (g/kg DM), chemical composition (g/kg DM), essential amino acids (g/kg DM) and content of metabolizable energy (ME, MJ/kg DM) of experimental diets for weaner pigs (experiment 1)

	Crude protein (Percentage in DM)				
Parameters	14	16	18	20	22
Ingredients					
Rice bran	180.0	150.0	150.0	125.0	110.0
Maize	640.0	610.0	550.0	525.0	490.0
Soybean meal	155.0	220.0	280.0	340.0	395.0
Soybean oil	20.0	15.0	15.0	5.0	-
Vitamin-mineral premix*	2.5	2.5	2.5	2.5	2.5
NaCl	2.5	2.5	2.5	2.5	2.5
Chemical composition					
DM	865.0	866.0	864.0	870.0	862.0
CP	139.0	161.0	181.0	203.0	222.0
CF	68.0	66.0	69.0	67.0	67.0
NDF	183.0	171.0	173.0	164.0	159.0
ADF	104.0	97.0	101.0	96.0	94.0
Essential amino acids					
Arginine	7.3	8.7	10.0	11.3	12.5
Histidine	2.9	3.3	3.6	4.0	4.4
Isoleucine	5.2	6.2	7.1	8.0	8.9
Leucine	13.1	14.5	15.5	16.8	17.9
Lysine	7.5	9.3	11.0	12.6	14.2
Methionine	2.8	3.1	3.3	3.5	3.8
Phenylalanine	5.4	6.3	7.0	7.8	8.6
Threonine	4.8	5.6	6.3	7.0	7.7
Tryptophan	1.4	1.6	1.9	2.1	2.3
Valine	6.0	6.8	7.6	8.4	9.1
ME[1]	13.9	14.0	14.1	14.1	14.1

*1 kg of vitamin and mineral premix contained: vitamin A 650 mg (325,000 IU); vitamin D_3 750 mg (75,000 IU); vitamin E 150 mg (75 IU); vitamin B_{12} 1 mg; vitamin K_3 80 mg; riboflavin 300 mg; niacinamide 1,200 mg; pantothenic acid 540 mg; choline chloride 6,000 mg; Fe 4,700 mg; Zn 6,500 mg; Mn 4,500 mg; Cu 1400 mg and carrier material 973.16 g. [1]Calculated values for growing pigs from analyzed chemical composition according toINRA (www.evapig.com, version 1.3.0.2)

Table 3: Ingredient composition (g/kg DM), chemical composition (g/kg DM), essential amino acids (g/kg DM) and content of Metabolizable Energy (ME, MJ/kg DM) of experimental diets for grower pigs (experiment 2)

	Crude protein (Percentage in DM)				
Parameters	11	13	15	17	19
Ingredients					
Rice bran	400.0	420.0	400.0	340.0	330.0
Maize	500.0	430.0	410.0	415.0	350.0
Soybean meal	75.0	135.0	180.0	240.0	305.0
Soybean oil	20.0	10.0	5.0	-	-
Vitamin-mineral premix*	2.5	2.5	2.5	2.5	2.5
NaCl	2.5	2.5	2.5	2.5	2.5
Chemical composition					
DM	872.0	883.0	867.0	870.0	860.0
CP	111.0	132.0	148.0	168.0	192.0
CF	109.0	117.0	116.0	107.0	108.0
NDF	278.0	290.0	282.0	258.0	255.0
ADF	177.0	188.0	184.0	166.0	167.0
Essential amino acids					
Arginine	5.4	6.7	7.7	9.0	10.5
Histidine	2.2	2.5	2.8	3.2	3.6
Isoleucine	3.8	4.7	5.4	6.4	7.4
Leucine	9.9	10.9	11.9	13.4	14.7
Lysine	5.2	6.9	8.1	9.8	11.7
Methionine	2.2	2.4	2.6	2.9	3.1
Phenylalanine	4.0	4.8	5.4	6.3	7.1
Threonine	3.6	4.3	4.9	5.7	6.5
Tryptophan	1.2	1.4	1.6	1.8	2.1
Valine	4.7	5.4	6.0	6.9	7.7
ME[1]	12.7	12.5	12.6	12.8	12.9

Table 4: Ingredient composition (g/kg DM), chemical composition (g/kg DM), essential amino acids (g/kg DM) and content of metabolizable energy (ME, MJ/kg DM) of experimental diets for finisher pigs (experiment 3)

	Crude protein (Percentage in DM)				
Parameters	9	11	13	15	17
Ingredients					
Rice bran	460.0	400.0	420.0	400.0	340.0
Maize	490.0	500.0	430.0	410.0	415.0
Soybean meal	20.0	75.0	135.0	180.0	240.0
Soybean oil	25.0	20.0	10.0	5.0	-
Vitamin-mineral premix*	2.5	2.5	2.5	2.5	2.5
NaCl	2.5	2.5	2.5	2.5	2.5
Chemical composition					
DM	873.0	872.0	883.0	867.0	870.0
CP	89.0	111.0	132.0	148.0	168.0
CF	118.0	109.0	117.0	116.0	107.0
NDF	318.0	278.0	290.0	282.0	258.0
ADF	205.0	177.0	188.0	184.0	166.0
Essential amino acids					
Arginine	3.8	5.4	6.7	7.7	9.0
Histidine	1.7	2.2	2.5	2.8	3.2
Isoleucine	2.7	3.8	4.7	5.4	6.4
Leucine	8.1	9.9	10.9	11.9	13.4
Lysine	3.2	5.2	6.9	8.1	9.8
Methionine	1.8	2.2	2.4	2.6	2.9
Phenylalanine	3.0	4.0	4.8	5.4	6.3
Threonine	2.7	3.6	4.3	4.9	5.7
Tryptophan	0.9	1.2	1.4	1.6	1.8
Valine	3.7	4.7	5.4	6.0	6.9
ME[1]	12.5	12.7	12.5	12.6	12.8

*1 kg of vitamin and mineral premix contained: vitamin A 650 mg (325,000 IU); vitamin D_3 750 mg (75,000 IU); vitamin E 150 mg (75 IU); vitamin B_{12} 1 mg; vitamin K_3 80 mg; riboflavin 300 mg; niacinamide 1,200 mg; pantothenic acid 540 mg; choline chloride 6,000 mg; Fe 4,700 mg; Zn 6,500 mg; Mn 4,500 mg; Cu 1400 mg and carrier material 973.16 g. [1]Calculated values for growing pigs from analyzed chemical composition according toINRA (www.evapig.com, version 1.3.0.2)

Experiment 3: A total of 30 female Moo Lath pigs with an initial BW of 39.9 (±1.80) kg and of the same age (around 9 months) were used in the experiment. They were fed experimental diet for 42 days, from 22 July to 1 September, 2011.

Feeding and management: The diets were offered in mash form with addition of water (2:1 w/w) at feeding. Feed was given *ad libitum* twice daily at 7.00 a.m. and 4.00 p.m. Water was available through drinking nipples all the time.

Pigs were housed in individual pens (1.0×2.0 m) with concrete floor. The pens were disinfected before the experiment and were cleaned daily with water before feeding during the experiment.

Sample collection and measurements: The same procedure was applied for all three experiments. Samples of feeds for chemical analysis were collected weekly. Feed refusals were collected, weighed and recorded daily and pooled to weekly samples for Dry Matter (DM) determination. The animals were weighed at the start of the experiment and thereafter weekly.

Chemical analysis: The samples were analysed for DM, ash, Crude Fibre (CF) and Nitrogen (N) content according to AOAC (1990). Ash was determined by incineration in a muffle furnace at 550°C for 3 h. N was analysed by the Kjeldahl Method and CP was calculated as N×6.25. Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) were determined by the methods of Van Soest *et al.* (1991). The Gross Energy (GE) content was determined using automatic adiabatic bomb calorimeter (Gallenkamp, Heidelberg, Germany).

Statistical analysis: The data from all three experiments were analysed statistically by analysis of variance using the General Linear Model (GLM) of Minitab Statistical Software. The following statistical model was used for evaluation of treatment effects within each experiment:

$$Y_{ij} = \mu + t_i + e_{ij}$$

Where:

Y_{ij} = Feed consumption, average daily gain and feed conversion ratio
μ = Overall mean
t_i = Effect of dietary treatment
e_{ij} = Random error

Treatment means showing significant differences at the probability level of $p<0.05$ were compared using Tukey's pairwise comparison procedures.

RESULTS AND DISCUSSION

Experiment 1: Feed intake, final BW and Average Daily Gain (ADG) were affected by protein level in the diet ($p<0.05$) with greater final BW, ADG and Daily Feed Intake (DFI) both in total and as percentage of BW in pigs fed diets with 18% CP or higher (Table 5). Feed Conversion Ratio (FCR) was also affected by protein level in the diet ($p<0.05$) with lowest values for pigs fed diets with 20% CP or higher.

Experiment 2: Feed intake, final BW and ADG were affected by protein level in the diet ($p<0.05$) with highest final BW, ADG and DFI in pigs fed the diet with 15% CP (Table 6). The FCR was affected by protein level in the diet ($p<0.05$) with lowest values for pigs fed the diet with 15% CP.

Experiment 3: Final BW and ADG were affected by protein level in the diet ($p<0.05$) with greater final BW and ADG in pigs fed diets with 11% CP or higher (Table 7). The FCR was also affected by protein level in the diet ($p<0.05$) with lowest values for pigs fed diets with 11% CP or higher. Final BW and DFI were not affected ($p>0.05$) by protein level in the diet.

To the knowledge, this is the first study attempting to describe the dietary CP requirements for native Moo Lath pig at different stages of growth and fed a typical pig feed, based on rice bran and maize that is used by smallholder farmers in Lao PDR (Phengsavanh *et al*., 2011). Soybean meal was used as the main CP source, firstly because it is the most commonly used protein source for pigs in Lao PDR and secondly because it provides most Essential Amino Acids (EAA) in the right proportions needed by growing pigs (NRC, 1998). Researchers decided not to supplement the diets with synthetic Amino Acids (AA) as this would not comply with the feeding practice of smallholder farmers in Lao PDR and this category of farmers are producing more than 85% of the pork in the country.

The Moo Lath weaner pigs did not show any improvement in performance traits above a dietary CP level of 18% in DM (12.8 g CP/MJ ME) (Fig. 1). These results were in accordance with studies from Thailand on wild boar (Wattanakul *et al*., 2004) and native pigs (Vasupen *et al*., 2004) and from Lao PDR on native Moo Lath pigs (Keonouchanh *et al*., 2008). The level of CP required for weaner Moo Lath pigs was lower than the level recommended by NRC (2012) for pigs in the BW range of 11-25 kg (21.0% CP in DM).

The Moo Lath grower pigs showed the greatest feed intake and ADG and the lowest FCR on the diet with 15% CP in DM (11.7 g CP per MJ ME) (Fig. 1). This result is supported by studies on protein requirements of native Mong Cai pigs in Vietnam (Ly *et al*., 2003; Pham *et al*., 2010). It was concluded from these studies that growing native Mong Cai pigs required around 13-14% CP in DM. Sirtori *et al*. (2010) reported that growing native Italian pigs of the Cinta Senese breed required around 13% of CP in the diet. The level of dietary CP required for growing

Table 5: Treatment effects of protein levels on performance of Moo Lath weaner pigs (experiment 1)

	Crude protein (Percentage in DM)					
Parameters	14	16	18	20	22	SEM
Initial weight (kg)	5.0	4.9	4.9	5.2	4.9	0.34
Final weight (kg)	11.9^{a}	12.6^{a}	17.7^{b}	21.8^{b}	21.6^{b}	1.03
Daily weight gain (g)	109.5^{a}	122.2^{a}	203.2^{b}	263.5^{b}	265.1^{b}	16.45
Daily feed intake (g)	274.3^{a}	290.3^{a}	497.7^{b}	537.2^{b}	543.8^{b}	70.29
Daily feed intake (BW %)	3.3^{a}	3.3^{a}	4.3^{b}	4.5^{b}	4.5^{b}	0.48
Feed per gain (kg kg^{-1})	2.5^{a}	2.4^{a}	2.4^{a}	2.0^{b}	2.1^{b}	0.28

Table 6: Treatment effects of protein levels on performance of Moo Lath grower pigs (experiment 2)

	Crude protein (Percentage in DM)					
Parameters	11	13	15	17	19	SEM
Initial weight (kg)	20.4	20.0	20.5	20.5	20.2	0.32
Final weight (kg)	36.9^{a}	39.8^{bc}	43.8^{c}	38.6^{ab}	38.3^{ab}	0.89
Daily weight gain (g)	350.7^{a}	420.2^{bc}	497.8^{c}	386.8^{ab}	384.7^{ab}	17.83
Daily feed intake (g)	1235.5^{a}	1382.0^{ab}	1536.7^{b}	1308.6^{a}	1293.1^{a}	58.23
Daily feed intake (BW %)	4.1^{a}	4.3^{a}	4.8^{b}	4.2^{a}	4.2^{a}	0.19
Feed per gain (kg kg^{-1})	3.5^{a}	3.2^{ab}	3.0^{b}	3.4^{a}	3.4^{a}	0.16

Table 7: Treatment effects of protein levels on performance of Moo Lath finisher pigs (experiment 3)

	Crude protein (Percentage in DM)					
Parameters	9	11	13	15	17	SEM
Initial weight (kg)	39.8	40.0	40.5	39.5	39.7	1.80
Final weight (kg)	54.4^{a}	60.2^{b}	61.2^{b}	58.8^{b}	58.6^{b}	2.04
Daily weight gain (g)	347.2^{a}	481.3^{b}	495.6^{b}	461.5^{b}	452.0^{b}	18.18
Daily feed intake (g)	1805.3^{a}	1972.8^{a}	2178.6^{a}	1982.2^{a}	1892.0^{a}	70.54
Daily feed intake (BW %)	3.8^{a}	4.0^{a}	4.3^{a}	4.0^{a}	3.8^{a}	0.10
Feed per gain (kg kg^{-1})	5.2^{a}	4.1^{b}	4.4^{b}	4.3^{b}	4.2^{b}	0.44

$^{a-c}$Means within rows with different superscripts differ significantly ($p<0.05$)

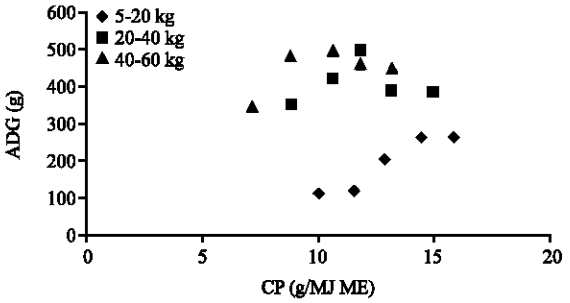

Fig. 1: The relationship between dietary Crude Protein (CP) level (g/MJ ME) and Average Daily Gain (ADG, g) in weaner (5-20 kg), grower (20-40 kg) and finisher (40-60 kg) Moo Lath pigs

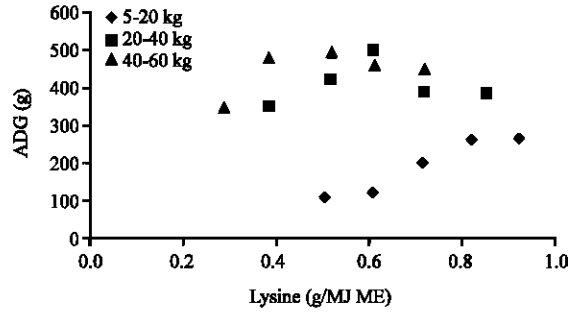

Fig. 2: The relationship between dietary lysine level (g/MJ ME) and average daily gain (ADG, g) in weaner (5-20 kg), grower (20-40 kg) and finisher (40-60 kg) Moo Lath pigs

Moo Lath pigs was lower than recommended by NRC (2012) for growing pigs in the BW range of 25-50 kg (17.4% CP in DM).

The Moo Lath finisher pigs showed the greatest final live weight and ADG and the lowest FCR on the diet with 11% CP in DM (8.7 g CP/MJ ME) or higher (Fig. 1) while feed intake was unaffected by dietary CP level. The results are supported by results from studies on native Moo Lath pigs (Keonouchanh *et al*., 2008) and native Mong Cai pigs (Ly *et al*., 2003) suggesting that Moo Lath and Mong Cai pigs weighing >40 kg required a dietary CP level 11-12% in DM. The level of dietary CP required for finisher Moo Lath pigs was lower than recommended by NRC (2012) for growing pigs in the BW range of 50-75 kg (15.2% CP in DM).

The total dietary lysine content (per kg DM) above which there was no further improvements in performance in the present study was 11.0, 6.9 and 5.2 g in weaner, grower and finisher pigs, respectively. This corresponds to a total lysine to energy ratio (g/MJ ME) of 0.78, 0.55 and 0.41 in the diet for weaner, grower and finisher pigs, respectively (Fig. 2). The NRC (2012) requirements for total dietary lysine (per kg DM) for growing pigs in the BW range of 11-25, 25-50 and 50-75 kg is 15.5, 12.4 and 10.8 g, respectively. This corresponds to a total lysine to energy ratio (g/MJ ME) of 1.0, 0.81 and 0.70 for growing pigs in the BW range of 11-25, 25-50 and 50-75 kg, respectively. Thus, the lysine required per unit ME (g/MJ ME) by weaner, grower and finisher Moo Lath pigs corresponds to 78, 68 and 58% of those recommended by NRC (2012) for growing pigs in the BW range of 11-25, 25-50 and 50-75 kg, respectively.

It can be concluded that Moo Lath pigs at all stages of growth (weaning, growing and finishing) require less dietary CP and lysine than the levels recommended by the NRC (2012) for growing pigs with comparable BW. The native Moo Lath pig as well as other native Lao pig breeds belongs to an un-improved pig genotype. They can all be characterized as fat-pig-genotypes with low capacity for lean meat deposition as compared with genetically improved pig breeds used as the basis for recommendations by the NRC (1998, 2012) and therefore they require less protein and EAA per kg of feed than leaner and fast growing genotypes (Bikker *et al*., 1994; Pham *et al*., 2010).

CONCLUSION

It is suggested that reasonable target levels for CP (in DM) in feed formulation for growing Moo Lath pigs should be 18% for weaners, 15% CP for growers and 11% CP for finishers. Further studies should be performed to establish more precise protein and EAA requirements for growing Moo Lath pigs.

IMPLICATIONS

The results of present study will have direct impact on smallholder pig farming in Lao PDR as it gives guidelines for reasonable levels of CP in the diet for growing native Lao pigs. The proposed levels of CP are markedly lower than recommended and used earlier and which were based on recommendations for other pig genotypes. The use of lower dietary CP levels in feed formulation to native growing Lao pigs will make it possible to use a wider range of available feed resources. This will have positive impact on the pig productivity in smallholder farms and will lead to increasing the number fattening cycles per year.

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