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THE USE OF CRUDE PALM OIL IN FINISHING PIGS' DIET: EFFECTS ON GROWTH PERFORMANCE AND NUTRIENT DIGESTIBILITY

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ABSTRACT

The goal of this study was to evaluate the effect of including crude palm oil (CPO) in the diet of finishing pigs in terms of growth performance and nutrient digestibility. In the first experiment, 40 barrows and 40 gilts (Duroc×LargeWhite×Landrace) were divided into five groups using a randomized complete block design. CPO, soybean oil (SBO) and poultry fat (PF) were mixed and divided into CPOmix11 (CPO 50% + PF 50%), CPOmix13 (CPO 50% + SBO 50%), CPOmix21 (CPO 75% + PF 25%) and CPOmix23 (CPO 83% + PF 17%). Each group of pigs was randomly fed two diets at 50-80 and 80-100 kgBW. Group 1 comprised the pigs fed diet10 (without oil inclusion) and diet20 (without oil inclusion). Group 2 comprised the pigs fed diet11 (1% CPOmix11) and diet21 (1% CPOmix21). Group 3 comprised the pigs fed diet13 (3% CPOmix13) and diet23 (3% CPOmix23). Group 4 comprised the pigs fed diet10 and diet 21. Group 5 comprised the pigs fed diet10 and diet23. The results showed that the pigs fed diet23 (Group 5) at 80-100 kgBW tended to have the greatest performance and lowest feed cost. In the second experiment, nutrient digestibility was examined in six barrows (initial 50 kgBW) using a 3×3 double Latin square design. Each set of two pigs was randomly fed diet10, diet11 or diet13. The highest ($P<0.01$) digestibility of dry matter, protein, crude fiber and ash and the greatest ($P<0.01$) digestible energy and metabolizable energy were found in diet13. The inclusion of 3% CPOmix23 in the diet at80-100 kgBW might improve finishing pig performance, and the 3% of CPOmix13 in the diet improved nutrient digestibility.

Keywords: *crude palm oil, finishing pigs, growth performance, nutrient digestibility.*

INTRODUCTION

Fats and oils have the highest average energy density of all macronutrients. Besides having high caloric value, some fats and oils like crude palm oil(CPO) can be a primary source of essential fatty acids, which cannot be synthesized by pigs, as well as fat-soluble vitamins and antioxidants such as phytosterols, tocopherols and carotenoids that help preserve and stabilize fats.

These micronutrients are essential for animal health, growth and carcass quality. Moreover, the use of particular types of fats and oils in pig rations affect the metabolizable energy of the total rations beyond the calculated energy of the diet. Finally, fats and oils can play a significant role in creating pelleted products and controlling mill and barn dust. CPO is extracted from the mesocarp of the fruit of the oil palm tree, Elaeis guineensis. Palm oil and its refinery products are now consumed worldwide as cooking oil and in a wide variety of foodstuffs (Pantzaris, 1995).

CPO has a dark orange-red color due to its high carotenoid content. It is also a rich source of vitamin E, namely tocopherols and tocotrienols (Nesaretnam and Muhammad, 1993). Both β-carotene and vitamin E are well-known nutritional antioxidants. The over-expanding production of palm oil in Thailand and other tropical countries offers the possibility of an increased and constant availability of CPO-based feedstuff for pig feed formulations. The chemical and energy demands of the palm oil refining process could be reduced. CPO could be used as energy feedstuffs directly.

The objective of this study was to evaluate the effect including CPO in the diet had on growth performance and nutrient digestibility in finishing pigs.

MATERIALS AND METHODS

This experiment was conducted in 40 barrows and 40 gilts (Duroc×LargeWhite×Landrace), which were dividedintofivegroups using a randomized complete block design. CPO, soybean oil (SBO) and poultry fat (PF) were mixed and divided into CPOmix11 (CPO 50% + PF 50%), CPOmix13 (CPO 50% + SBO 50%), CPOmix21 (CPO 75% + PF 25%) and CPOmix23 (CPO 83% + PF 17%). Each group of pigs was randomly fed two diets at50-80 and 80-100 kgBW.

Group 1 included the pigs fed diet10 (0% oil) and diet20 (0% oil).
Group 2 included the pigs fed diet11 (1% CPOmix11) and diet21 (1% CPOmix21).
Group 3 included the pigs fed diet13 (3% CPOmix13) and diet23 (3% CPOmix23).
Group 4 included the pigs fed diet10 and diet21.
Group 5 included the pigs fed diet10 and diet23.

The composition and proximate analysis of the diets are shown in Table 1. The nutrient compositions of all of the diets followed NRC (1998) recommendations. The pigs were housed 8 pigs to a pen, whichgavethe*ad libitum* access to feed and water.The pigs'body weights and feed consumption were recorded and measured from the beginning of the trial to a final average live weight of 100±5 kg to calculate theiraverage daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (Feed: Gain; FCR).

In experiment 2, thetotal tract digestibility (%) of DM, crude protein (CP), crude fiber (CF), EE and ash were determined, and the dietary energy (DE) and metabolizable energy (ME) were calculatedin six barrows (initial 50 kgBW) using a3×3 double Latin square design. Titanium dioxide (TiO_2) was added to the feed at a dose of 0.5% for the duration of sevendays as an indigestible marker for digestibility determination.Each set of two pigs were randomly fed diet10, diet11 or diet13 for 7dwith a 4d adjustment period. They were then maintained for a 3d collection period. Fresh fecal samples were mixed, pooled, and stored in a freezer at -20ºC until they were analyzed. Before chemical analysis, each fecal sample was thawed and dried at 60ºC for 72 h, after which it was finely ground to 1-mm sized grains.

All feed and fecal sampleswere then analyzed for DM, CF, EE and N according tothe procedures outlined by the AOAC (1995). TiO_2 was analyzed using UV absorption spectrophotometry according tothe method described by Short et al. (1996), Kavanagh et al. (2001) and Glindemann et al. (2009).The proper care and use of the animals in theseresearch procedures were approved by the Naresuan University Animal Care and Use Committee (NUACUC No.57 04 0031).

All data were subjected to statistical analysis by one-way analysis of variance (ANOVA) using the SPSS statistical software (Ver. 15 for Windows, SPSS Inc., Chicago, IL, USA). Differences among treatments were examined using Duncan's multiple range tests, which were considered significant at $P<0.05$. The means and standard errors of the means are presented.

Table 1. Dietary treatment composition for finishing pigs 1 (50-80 kgBW) and finishing pigs 2 (80-100 kgBW).

Items	Finishing pig diets 1			Finishing pig diets 2		
	10	**11**	**13**	**20**	**21**	**23**
Ingredients (g/kg as fed basis)						
Corn	330	500	50	704	364	200
Broken rice	330	135	520	-	305	404
Soybean meal	200	205	180	155	150	145
Defatted rice bran	120	130	200	120	150	200
Crude palm oil	-	5	15	-	7.5	25
Soybean oil	-	-	15	-	-	-
Poultry fat	-	5	-	-	2.5	5
Lysine	10	10	10	1	1	1
Di-calcium phosphate (P18)	5	5	5	4	4	3
CaCo3	2.5	2.5	2.5	11	11	12
Salt	2.5	2.5	2.5	2.5	2.5	2.5
Vitamin and mineral premix[b]	330	500	50	2.5	2.5	2.5
Calculated composition (g/kg DM basis)						
Metabolizable energy (Kcal/kg)	3187	3237	3255	3217	3218	3260
Protein	155	155	155	132.1	138.8	141.3
Fiber	29.3	31.0	28.3	43.8	41.9	45.0
Ether extract	7.6	15.3	38.8	31.6	30.4	44.2
Calcium	5.3	5.3	5.3	6.0	6.0	6.2
Total phosphorus	6.7	7.0	7.4	5.7	5.8	6.2
Lysine	8.1	8.2	7.8	7.8	7.8	7.8
Methionine+ cystine	5.4	5.6	5.1	5.2	5.0	4.9
Tryptophan	3.7	4.5	2.1	5.3	3.6	2.7
Threonine	5.9	6.0	5.6	5.3	5.2	5.1
Fatty acid Composition						
Total unsaturated fatty acid	9.0	16.9	19.0	16.2	12.8	14.3
Total saturated fatty acid	1.6	5.1	7.0	2.8	4.5	9.4
[a]U:S ratio	6.02	4.04	3.91	6.2	3.90	3.02
[c] CPOmix cost (Baht/kg)	-	25.00	37.50	-	25.00	25.00
[c] *Feed cost (Baht/kg.)*	13.11	13.80	12.96	12.77	12.50	12.61

[a] U:S ratio = Unsaturated fatty acid: Saturated fatty acid

[b] Vitamin and mineral premix provided per kilogram of diet: 450 mg Fe; 400 mg Cu; 250 mg Zn; 150 mg Mn; 0.5 mg I; 0.25 mg Se; 8,000 IU vitamin A; 2,000 vitamin D_3; 37.5 mg vitamin E; 0.925 mg vitamin K-3; 8.43 mg vitamin B_2; 0.04 mg vitamin $B_{12;}$ 34.5 mg nicotinic acid; 26 mg pantothenic acid

[c] Theprice of feed ingredients calculated during July-September 2015

RESULTS AND DISCUSSION

As the experiment only had two replications per treatment that were housed in groups (8 pigs per group), statistical analysis could not support it. The results shown in Table 2 only demonstrate the tendency of the pigs in groups 2 to 4 to have smaller experimental periods, FCRs and feed costs. In agreement with previous research, the addition of fat and oil in this research has been reported to improve feed efficiency (Goodband et al., 1989; DeRouchey et al., 2007; and Shannon, no date). Feed efficiency did not significantly differ by type of fat source (Park et al., 2012).The pigs in group 5, which were fed with diet10 (50-80kgBW) and diet23 (80-100 kgBW), tended to have the lowest FCR and feed cost. According to DeRouchey et al. (2007) and Shannon (no date), for each 1% of added fat in grower-finishing pigs, feed efficiency is usually improved 1.8%. Meanwhile, the ADG is reported to increase approximately 2% in grower diets and 1% in late finisher diets for each 1% of added fat. Additionally, previous research found that the inclusion of 4% of fat from soybean oil, coconut oil or choice white grease showed an increase in feed intake and feed efficiency compared with the non-fat control (Goodband et al., 1989). The current study did not find any effects of gender on the pigs' FCR. However, it was found that barrows tended to have better ADG than gilts. This differs from previously published research (Latorre et al., 2003; Serrano et al., 2013; Tartrakoon et al., 2016). The different results of the current study might be related to the type of oil or fat supplementation.

Table 2**.** Effect of dietary treatments on growth performance of finishing pigs (50-100 kgBW)

Items	Group[a]					Gender[b]	
	1	2	3	4	5	**B**	**G**
Initial weight, kg	50.08	50.20	50.03	49.86	49.95	50.01	50.03
Final weight, kg	100.01	99.95	100.45	100.16	100.65	100.24	100.24
Weight gain, kg	49.93	49.75	50.42	50.30	50.70	50.23	50.21
Period of trial, d	84.00	72.00	71.00	69.50	70.00	67.60	79.00
Average daily feed intake, kg/d	2.26	2.23	1.80	1.95	1.68	2.12	1.84
Average daily gain, kg/d	0.60	0.71	0.72	0.73	0.73	0.75	0.64
Feed conversion ratio (FCR)	3.32	2.91	2.54	2.73	2.31	2.72	2.79
Feed cost, Baht/kgWG	42.46	37.92	32.47	34.36	29.37	34.86	35.71

[a]Group1, the pigs fed diet without oil inclusion in diet10 and diet20; Group2, the pigs fed diet11 and diet21; Group3, the pigs fed diet13 and diet23; Group4, the pigs fed diet10 and diet21; Group5, the pigs fed diet10 and diet23 at50-80 and 80-100 kgBW, respectively.

[b]B = Barrows; G = Gilts

Improving the FCR or feed efficiency of the pigs' fed diets supplemented with fat and oil could also be supported by the 2nd experiment in this research. The highest ($P<0.05$) digestibility of dry matter, protein, crude fiber, ash and the greatest

(P<0.05) digestible energy and metabolizable energy were found in the pigs fed diet13, which was 3% CPOmix13. It may be due to the fact that the oil in CPOmix13 was plant oil and that the higher nutrient digestible was found indiet11, which contained CPO11 (50%CPO+50%PF). These two groups were different not only because of the type of oil or fat but also because of the inclusion level of diet13, which was 3%CPOmix13. The explanation could be supported by the results of Albin et al., (2001) who found that adding high levels of soybean and palm oil to a semi-purified swine diet increased the apparent ileal digestibility of some amino acids. Also, the fat sources affected some apparent ileal amino acid digestibility (Albin et al., 2001), digestible energy and ether extract digestibility (Mitchaothai et al., 2008; Yongbo et al., 2015).

When fat is oxidized, ADG and ADFI in nursery pigs will decrease; however, free fatty acid (FFA) concentrations of at least 53% in choice, white grease fat does not adversely affect its utilization in nursery pigs (DeRouchey et al., 2004). The FFA analysis results of fat and oil source and experimental diet in Table 4 showed the highest FFA in CPO and the lowest FFA in SBO. After the oil was mixed into CPOmix11, which contained 50% CPO+50% PF in diet11 at a 1% inclusion level, a significantly higher FFA concentration was found in diet11 than the control, diet10 (2.03% vs. 1.67%). However, there was no significant difference in the FFA concentrations of diet11 and diet 13 (CPOmix13, 50%CPO+50%SBO)

Table 3**.** Total tract nutrient digestibility (%) of finishing pigs fed experimental diets

Treatments	**Total tract digestibility (%)**[e]						**Energy**[f]	
	DM	**CP**	**CF**	**EE**	**Ash**	**Energy**	**DE**	**ME**
Diet10	91.75[c]	92.45[c]	74.59[c]	97.52[a]	78.82[c]	91.32[c]	3,441[b]	3,376[b]
Diet11	92.94[b]	93.63[b]	78.89[b]	97.15[ab]	82.41[b]	92.83[b]	3,567[a]	3,501[a]
Diet13	94.98[a]	95.61[a]	84.70[a]	96.61[b]	87.25[a]	94.36[a]	3,646[a]	3,577[a]
[d]SEM	0.37	0.38	1.18	0.15	0.98	0.37	25.97	25.17

[a,b,c]Means within rows with different superscripts differ (*P*<0.05)
[d]SEM = Standard error of the mean
[e]DM = Dry matter; CP = Crude protein; CF = Crude fiber
[f] DE = Digestible energy (kcal/kg); ME= Metabolizable energy (kcal/kg)

Table 4. Free fatty acids content (%) in oil, fat and experimental diet.

Oil and Fat[d]			**Experimental Diet** [c]			**SEM** [e]	**p-value** [f]
CPO	**PF**	**SBO**	**Diet10**	**Diet11**	**Diet13**		
8.71	4.31	0.25	1.67[b]	2.03[a]	1.80[ab]	0.069	*

[a,b]Means within rows with different superscripts differ (P<0.05)
[c] Diet10, the pigs fed diet without oil inclusion; Diet 11, diet comprised CPOmix11 (50% CPO+50%PF); Diet13, diet comprised CPOmix13 (50%CPO+50%SBO).
[d] CPO = Crude palm oil; PF = Poultry fat; SBO = Soybean oil
[e] SEM = standard error of the mean; [f]*= P<0.05

CONCLUSION

The inclusion of CPOmix23 (83%CPO+17%PF)as 3% ofthe diet at80-100 kgBW of the pigs might improve finishing pig performance, andCPOmix13 (50%CPO+50%SBO)as 3% of the diet improves nutrient digestibility.

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