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Effect of Rice Bran Quality and Protein Supplement, Base Mix, and/or Soybean Meal on Growing Pig Performance in Cambodia

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Abstract

The objective of this study was to evaluate the effect of rice bran quality and dietary supplement source on growing pig performance. A total of 60 castrated male pigs (Yorkshire × Duroc, initially 16.1 kg) were used for 52-day trial. Pigs were allotted to pens in a completely randomized design (4 pigs per pen) and assigned to four dietary treatments in a 2 × 2 factorial with factors being rice bran source (high or low-quality) and source of protein, vitamins, and minerals (supplement or soybean meal and base mix). Analyzed protein and fat level for the high- and low-quality rice bran was 11.07% and 5.86% and 11.20% and 4.50%, respectively. Crude fiber content for high- and low-quality rice bran was 13.44% and 27.79%. Diets were formulated in two phases (phase 1: 16 to 27 and phase 2: 27 to 48 kg) to adjust to the pig's nutrient requirements. There was no evidence for an interaction (P > 0.05) between rice bran quality × supplement type or main effect of supplement type (soybean meal + base mix vs protein supplement) for final body weight, average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (F/G). However, pigs fed high-quality rice bran had improved (P < 0.001) ADG and F/G and lower ADFI compared to pigs fed low protein rice bran. In conclusion, rice bran quality as measured by protein, crude fiber, and fat influenced growing pig performance, while the type of dietary protein supplement did not. Additionally, rice bran with high protein, fat, and low fiber improved ADG and F/G.

Keywords

Base Mix, Pigs, Protein Supplement, Rice Bran, Soybean Meal

1. Introduction

Animal production has the potential to improve human wellbeing and prosperity in resource poor communities around the world. In Cambodia, pig production makes an important contribution to farm and family incomes [1]. Although the Ministry of Agriculture, Forestry, and Fisheries [2] reported that the number of pigs raised in Cambodia to be 2,185,924 heads, consumer demand for pork exceeds the countries production capacity (estimated at 153 thousand ton). In terms of local production, 75% of total pig producers are farmers living in the rural provinces of Cambodia [3]. Commonly, these small farm-households raise pigs in small numbers, utilizing traditional farm management techniques [4]. This includes feeding ingredients that are commonly available in Cambodia, such as rice bran, banana stem, sweet potato vine, water spinach, water hyacinth, duckweed, and other non-conventional feed [5]. Rice bran is a by-product of processing paddy rice for human food and is often used as an ingredient in mixed pig feed [6]. Due to its interesting chemical composition and particularly high lysine and methionine content, rice bran is often used as a basal diet in pigs [5] [7] [8] [9] [10]. Rice bran can be a mixture of by-products obtained from different stages of the milling process, which results in large variations in its chemical composition. In Cambodia, rice bran is used in up to 50% of the feeds for pigs [1] and it is commonly marketed based upon three grades (1, 2, and 3) according to their nutritional value and physical texture. Cambodian rice bran, produced by traditional mills, has low energy density and protein [5]. The classification of rice bran grade is based on qualifications of rice mills, machinery, rice milled processing, and price of rice bran in the region [1]. There is a large variation in the nutrient quality of rice bran in Cambodia where Sreng [11] recently reported crude protein ranges of 13.20%, 10.86% and 7.32% crude protein for rice bran grades 1, 2, and 3, respectively. Also, crude fiber levels were found between grades 1, 2 and 3 with values of 15.57%, 15.31% and 26.22%. Rice bran purchased from mills producing grade 3 rice bran based on nutrient profile may result in slower growth and lower performance and productivity of pigs, due to lower levels of energy, protein [10] and minerals [12]. Cambodian farmers are often aware of this fact and often mix rice bran with other protein sources to improve pig growth.

Commercial protein supplements are often purchased and utilized by Cambodian farmers to mix with rice bran or other grain sources in pig diets. These protein supplements are a good source of protein and may include some vitamins and minerals. However, they are expensive, and farmers often cannot afford to feed them at recommended levels. This leads to farmers adding reduced levels of protein supplements to pig diets, which does not ultimately lead to improved nutrition outcomes for pigs. Additionally, some small-scale farmers will purchase vitamins and mineral, available as a base mix or premix, in an attempt to provide better nutrients to pig diets. However, it has been shown that the addition of a base mix or premix to rice bran does not provide sufficient protein to

meet the nutrition requirements for pigs [13]. Currently there is a lack of research evaluating different rice bran sources with soybean meal, commercial protein supplements or the addition of a base mix to rice bran-based diet. Thus, the objective of this study was to evaluate the effect of rice bran source and supplement source (commercial supplement or soybean meal and base mix) on growth performance of growing pigs.

2. Material and Methods

2.1. Location and Duration

This study was conducted in an on-farm setting in a farmer's pig barn facility located in Kandal province, approximately 20 km from Phnom Penh, Cambodia. The study was conducted over a 3-month period, during the dry season (April to June 2019). The average daily temperature of 31˚C (maximum at 32˚C and minimum at 29˚C) and 74% humidity (range 66% - 81%). The Kansas State University Institutional Animal Care and use committee approved the research of this experiment.

2.2. Animal and Management

A total of 60-castrated-pigs (Yorkshire × Duroc), with a starting weight of approximately 16 kg, were randomly assigned, in a completely randomized design, to individual pens (2 × 3 m) with free access to one feeder and one available water drinker. Four pigs were assigned to each pen, based on starting body weight to achieve an equal starting weight across the four-feeding comparison. Pigs were vaccinated against *Mycoplasma*, foot and mouth disease, porcine respiratory and reproductive syndrome, and classical swine fever and also were treated Bendazole to kill roundworms before starting the experiment.

2.3. Feed and Feeding

The experiential diets consisted of soybean meal, protein supplement, two grades of rice bran and base mix. Feed ingredients were purchased from a local feed store and rice milling near the experimental farm, except base mix, which was purchased from Provimi Company in Vietnam. Pigs were fed with complete feed (Higro 550, CP Cambodia Co., Ltd.) for 4 days during pen adaptation and then pigs were adapted for 3 days with experimental trial diet before starting the experiment. Feed was mixed thoroughly one day prior to offering feed (Table 1).

Treatments were arranged in a 2 × 2 factorial with two rice bran sources (high or low-quality based on protein and fat content) and two supplement types (soybean meal plus base mix or protein supplement). There were 3 or 4 replications per treatment. Experimental diets were formulated in two phases according to stage growth of pigs: phase 1. Pigs with a body weight of 16 - 27 kg; and phase 2. Pigs with a body weight of 27 - 48 kg (Table 1). Diets using protein supplement contained a constant 20% inclusion rate for both phases, according to the recommendation of manufacturer. Soybean meal was reduced between phase 1

Table 1. Composition of basal diet used in the experiment (as-fed basis).

Diet	High-quality rice bran	Low-quality rice bran	Protein Supplement	Soybean Meal	Base mix[a]
Phase 1 (16 - 27 kg of body weight)					
Diet 1	72.5	-	-	25	2.5
Diet 2	80	-	20	-	-
Diet 3	-	72.5	-	25	2.5
Diet 4	-	80	20	-	-
Phase 2 (27 - 48 kg of body weight)					
Diet 1	79.5	-	-	18	2.5
Diet 2	80	-	20	-	-
Diet 3	-	79.5	-	18	2.5
Diet 4	-	80	20	-	-

[a]Composition of Base mix per kg: Vitamin A = 206,250 IU/kg; Vitamin D3 = 422,00 IU/kg; Choline = 13,700 mg/kg; Vitamin E = 1690 mg/kg; Vitamin B3 = 1240 mg/kg; Vitamin B5 = 685 mg/kg; Vitamin B2 = 206 mg/kg; Vitamin K = 84 mg/kg; Folic acid = 56 mg/kg; Vitamin B6 = 28 mg/kg; Biotin = 5.6 mg/kg; Vitamin B12 = 850 mg/kg; Fe ($FeSO_4$-H_2O) = 2750 mg/kg; Zn (ZnO) = 2750 mg/kg; Mn (MnO) = 825 mg/kg; Cu ($CuSO_4$-$5H_2O$) = 415 mg/kg; Se (Na_2SeO_2) = 7.4 mg/kg; I ($Ca(IO_3)_2$-H_2O) = 7.4 mg/kg; Lysine (L-Lysine HCL) = 3.3%, Methionine (DL-Methionine) = 0.95%; Threonine (L-Threonine) = 3.3%; Calcium ($CaCO_3$) = 20%, Digestible Phosphorus (DCP) = 5.6%; Salt (NaCL) = 12.5% and Carrier (Rice hull).

and 2 to match the changing requirements as pigs mature. Feed was given to pig ad libitum and was provided 4 times per day (at 07:00, 11:00, 16:00 and 18:00) so they were able to eat all that they wanted. Water was given to pig freshly and available for pig every time they needed.

2.4. Data Collection

Feed offered and residual feed were weighted and recorded daily to determine average of daily feed intake (ADFI). Sub-samples of both grades of rice bran and soybean meal were collected from every batch purchased to know the variation between purchases over time. Samples of treatment diets were collected every week and composite samples were sent to Chemical Analysis Laboratory, Royal University of Agriculture, Phnom Penh to analyzes the chemical composition. Residual feed samples were also sent to laboratory to analyze for dry matter to calculate feed intake on dry matter basis. Pigs were weighted individually on 0, 21 and 52 day of the experiment to calculate body weight (BW), average daily gain (ADG) and feed efficiency (F/G).

2.5. Chemical Analysis

Feed ingredients and experimental diets (offer and residues) were analyzed for their chemical composition (dry matter, crude protein, organic matter, crude fiber, and fat). Dry matter and organic matter were analyzed for proximate principle according to AOAC [14]. Crude protein was analyzed by LECO machine (FP-528, LECO Corporation, ISO-9001:2008, USA, 2014), Crude fiber was de-

termined by ANKOM 200i (ANKOM Technology, USA) approved procedure by AOCS and fat was determined by ST 243 Soxtec™ Extraction Unit (Foss Analytical Co., Ltd., China, 2014).

2.6. Data Analysis

Body weight, average of daily weight gain, feed intake and feed efficiency were analyzed as a randomized incomplete block design in a 2×2 factorial using SAS program. Sources of variation were two grades of rice bran (high-quality rice bran and low-quality rice bran), type of supplement (protein supplement and soybean meal with base mix) and error. The analytical procedure was processed with one-way of analysis of variance (ANOVA-test) to compare the variable means and determined the statistically significant difference of means at the probability level ($P < 0.05$).

3. Results

Chemical composition and variation of feed ingredients are shown in Table 2. High-quality rice bran had higher crude protein and fat, and lower crude fiber then the low quality rice bran, as expected, and was similar to grade 2 rice bran reported by Sreng [11]. For the low quality rice bran, its nutrient profile was generally consistent with a grade 3 rice bran, the poorest quality classification [11]. The protein supplement and soybean meal had similar values for crude protein and crude fiber content.

Diet analysis was similar to expectations based on the analysis of individual ingredients used in each diet. Diets containing high-quality rice bran had greater crude protein and fat and lower crude fiber than diets containing low-quality rice bran. As experimentally designed, crude protein of diets with soybean meal and base mix was approximately 2% greater during phase 1 than during phase 2. Decreasing the ratio of soybean meal in the diet decreased the percentage of total crude protein in diet. Due to supplement inclusion rates being similar in phase 1 and 2, diet analysis for diets containing supplement was similar in both phases (Table 3).

The effect of rice bran, protein supplement, base mix and soybean meal on the growth rate of pigs is shown in Table 4. Interactions between rice bran quality

Table 2. Chemical composition and variation of feed ingredients (%DM).

Items	High-quality rice bran	Low-quality rice bran	Soybean meal	Protein supplement
	n = 5	n = 6	n = 3	n = 1
Dry matter	92.91 ± 1.01	92.54 ± 0.92	90.82 ± 0.35	93.10
Crude protein	11.07 ± 1.15	5.86 ± 0.41	46.10 ± 0.64	46.43
Organic Matter	89.66 ± 2.07	85.08 ± 0.64	92.15 ± 0.08	81.94
Crude Fiber	13.44 ± 2.08	27.79 ± 1.59	3.57 ± 0.14	3.67
Fat	11.20 ± 0.93	4.50 ± 0.91	1.09 ± 0.35	4.44

Table 3. Chemical composition of diets[a].

Parameter	DM (%)	CP (%)	OM (%)	CF (%)	Fat (%)
Phase 1 (16 - 27 kg of body weight)					
HRB + SBM + BM	90.93	18.87	91.05	9.46	8.80
HRB + PS	91.64	16.30	90.33	10.31	8.30
LRB + SBM + BM	91.69	15.26	85.87	22.32	3.37
LRB + PS	91.96	12.73	85.05	25.3	3.48
Phase 2 (27 - 48 kg of body weight)					
HRB + SBM + BM	91.63	16.73	88.68	11.34	7.12
HRB + PS	92.79	16.81	88.91	11.71	8.42
LRB + SBM + BM	92.17	12.81	84.95	23.59	4.12
LRB + PS	91.37	12.95	84.81	23.48	5.14

[a]HRB = High-quality rice bran, LRB = Low-quality rice bran, SBM = Soybean meal, BM = Base mix, PS = Protein supplement.

Table 4. Effect of rice bran quality and protein supplement, base mix, and/or soybean meal on growing pig performance[d,e].

Item	HRB		LRB		SEM	P-value		
	SBM + BM	PS	SBM + BM	PS		Rice Bran Source	Protein Source	Rice Bran × Source
Body weight, kg								
D 0	16.14	16.20	16.12	16.12	0.04	0.262	0.416	0.416
D 21	26.79[a]	26.14[a]	24.40[b]	23.36[b]	0.06	<0.001	0.133	0.718
D 52	48.19[a]	48.12[a]	43.64[b]	42.91b	0.10	<0.001	0.668	0.717
Phase 1 (Day 0 - 21)								
ADG, g	507[a]	473[a]	394[b]	345[b]	26.8	<0.001	0.112	0.756
ADFI, g	1299[ab]	1209[b]	1325[a]	1267[ab]	34.9	0.211	0.038	0.616
F/G	2.58[b]	2.63[b]	3.36[a]	3.68[a]	0.17	<0.001	0.267	0.411
Phase 2 (Day 21 - 52)								
ADG, g	690[a]	709[a]	621[b]	631[b]	19.1	0.001	0.418	0.795
ADFI, g	2139[a]	1965[b]	2422[a]	2465[a]	75.1	<0.001	0.356	0.136
F/G	3.10[b]	2.78[c]	3.90[a]	3.91[a]	0.10	<0.001	0.123	0.097
Overall (Day 0 - 52)								
ADG, g	616[a]	614[a]	529[b]	515[b]	19.0	<0.001	0.640	0.740
ADFI, g	1800[b]	1660[b]	1979[a]	1981[a]	54.4	<0.001	0.188	0.173
F/G	2.93[b]	2.72[b]	3.74[a]	3.85[a]	0.12	<0.001	0.678	0.185

[a,b,c]Means within main effects within rows without common letter are different, P < 0.05; [d]HRB: High-quality rice bran, LRB: Low-quality rice bran, SMB: Soybean meal, BM: Base mix, PS: Protein supplement; [e]ADG: Average daily gain, ADFI: Average daily feed intake, F/G: Feed efficiency.

and supplement type or effects of supplement type (soybean meal + base mix or protein supplement) on body weight, ADG, ADFI and F/G at day 21, 52 and

overall were not significant in this study. However, rice bran quality significantly affected body weight, ADG, ADFI and F/G with pigs fed diets containing high-quality rice bran having improved (P < 0.001) ADG and F/G compared with pigs fed diets with lower quality rice bran during both phases and overall. Pigs fed diets containing high-quality rice bran also had lower ADFI (P < 0.001) from d 21 to 52 and overall than pigs fed low-quality rice bran.

For effect of added protein source to the diet, pigs fed diets with protein supplement had lower (P = 0.038) ADFI from d 0 to 21 than pigs fed diets containing soybean meal and base mix. However, no overall differences in growth or body weight were found between pigs fed either the protein supplement or soybean meal and base mix.

4. Discussion

High-quality rice bran in this study had a higher percentage of crude protein and fat and corresponding low crude fiber. In contrast, low-quality rice bran had lower percentage of crude protein and fat but a high percentage of crude fiber. Likewise, Samkol [1] reported that rice bran is classified into 3 grades (1, 2 and 3) based on crude protein, crude fiber content and market price. The third grade has significant amounts of husks which has a high content of fiber and poorer quality. However, a variety of factors associated with the rice grain itself and the milling process affect the chemical composition of rice bran [15] [16] [17]. The crude protein levels for rice bran in this study were 5.86% and 11.07%, which are within the range (3.37% to 16.20%) of other previous data [1] [7] [9] [13] [17] [18] [19] [20] [21]. The crude fiber levels of rice brans in the present study were 13.44% and 27.79% which agree with the others that reported crude fiber content of rice bran in ranges from 6.13% to 28.6% [9] [13] [15] [17] [18] [19]. Rice brans used in this study contained 4.5% and 11.2% fat which are similar to the range of 4.7% to 22.6% reported by Saunder [17]. The high- and low-quality rice bran would be considered grade 2 and 3 respectively, based on Samkol [1].

Soybean meal used in this experiment contained 46.10% crude protein (CP) which was lower than the result of Sreng [13] who reported that soybean meal contained 50.45% CP on dry matter (DM) basis. However, it was within the range (42.7% to 51.1%) of other reports [22]. The value of crude fiber and fat were 3.57% and 1.09%, which was similar to previous report [13] and were within the range of 2.8% to 7.7% for crude fiber and 0.5% to 2.6% for fat, respectively [22]. Wang [23] describe that soybean meal in different areas has different protein and AA concentrations. However, the differences in processing mill conditions such as temperature, moisture, residence time and fineness may result in soybean meal of varying quality and nutrient composition [22]. Soybean meal processors must ensure soybean meal is adequately processed to a high enough temperature to reduce anti-nutritional factors that result in decreased growth performance [24]. Analysis of protein supplement was confirmed that it has a high protein (46% CP). Chemical composition of diets including soybean

meal and base mix were changed as expected with the percentage of ingredient changes.

Type of supplements (soybean meal + base mix or protein supplement) did not influence body weight, ADG, and F/G from day 0 to 21, 21 to 52 and overall (d 0 to 52) of the study. These results indicate that both methods of supplementation provided adequate nutrients to achieve similar growth performance. Results also agree with Sreng [13] who found that feeding pig a rice bran diet with soybean meal and base mix compared to feeding a rice bran diet with high protein supplement had similar growth performance.

The quality of rice bran significantly affected final body weight (+11%), ADG (+18%), ADFI (−13%) and F/G (−26%) when comparing high vs. low-quality rice bran. The two rice bran sources had different percentage of crude protein, crude fiber and fat which was likely the main reason for differences in pig growth performance. High-quality rice bran diets improved ADG and F/G and decreased ADFI, which may have been caused by the high fat and low crude fiber content. The significantly higher crude fiber of the low-quality rice bran most likely contributed to the slower growth rate and poorer feed efficiency due to a lower energy content. This agreed with earlier reports by Chanphone [10] and Sikka and Chawla [25] who demonstrated that the quality of rice bran with respect to crude fiber affects the growth rates and digestibility in growing pigs. Also, ingredients with higher dietary fiber had decreased DE concentration of the diet [26]. Additionally, Samkol [1] reported that third grade of rice bran has a lot amount of husk and it has a high content of fiber, which pigs either do not or minimally digest.

Shi [16] showed that DE and ME content among 17 samples of rice brans ranged widely and correlated with fat. The differences in fat content between rice brans reflect difference in their energy content [27]. Low energy diets containing higher level of fiber will depress the growth rate under high environmental temperature. Cho [28] showed that increasing the energy density of the diet improved ADG and F/G on growing pig. Conversely, increased dietary fiber level is associated with a reduced available energy content of the feed [29]. Using prediction equations developed by Shi [16], the high-quality rice bran in our study contained 20% greater metabolizable energy than the low-quality rice bran (2886 kcal/kg vs 2290 kcal /kg, respectively).

Finally, the diets of high-quality rice bran also had a greater percentage of CP than diets with low-quality rice bran. Thus, the level of protein in the diet also may have affected the growth performance of pigs. Cunha [30] reported that if protein level in diet is low, it will decrease feed intake, rate of weight gain and feed efficiency. Moreover, significant reductions in body weight gain by using rice bran up to 82% in diet were associated with lower CP and NFE and reduced digestibility of nutrient [18]. There is considerable variation in the nutritive value of different samples of rice bran, as shown by large variation in amino acid digestibility values [27].

5. Conclusion

In conclusion, rice bran quality as measured by protein, crude fiber, and fat influenced growing pig performance but the type of dietary protein supplement did not. Rice bran with high protein, high fat, and low fiber improved ADG and F/G.

Acknowledgements

Conflicts of Interest

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

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