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By-product Originating from Artisan Distillers of Rice Alcohol in Northern Vietnam: Production, Use and Nutrient Value for Smallholder Pig Raising

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Abstract The objective of this study was to investigate by-product production originating from artisan distillers of rice alcohol and its use as pig feed in three provinces (Hai Duong, Hung Yen and Bac Giang) of Northern Vietnam. A total of 120 rice alcohol producers classified by production scales (30 producers for Large-L, 45 producers for Medium-M and 45 producers for Small-S) were interviewed from January to August 2015. Additionally, sixty-three rice distiller's by-product samples were collected from the study areas to determine their daily nutrient content according to one week storage time. The annual dry matter feedstuff production was estimated to 4.8, 3.0 and 2.1 tons per household for L, M and S scales, respectively ($p<0.001$). Swine herd size increased with the scale of household alcohol production ($p<0.05$). The proportion of rice distiller's by-product in diet of swine lowered when turning from pregnant to lactating sows, and varied in fattening pigs. Rice distiller's by-product was rich in high quality crude protein, copper and lactic acid but poor in dry matter. Its nutritive value remained stable over a week under ambient conditions. In conclusion, rice distiller's by-product provides significant and stable amounts of nutrients in northern vietnamese pig production.

Keywords: *artisan, rice distillers, nutrient, pig, Northern Vietnam*

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1. Introduction

In pig raising, feed cost accounts for a weighty portion (about 70%) of total production cost [1]. Pig producers often try to mitigate this problem by using agro industrial by-products derived from fermented products or agricultural processing plants as animal feed [2,3].

In developed countries, dried distillers grains with solubles (DDGS) - a cereal byproduct from ethanol production plants - are used as animal feed [1,4,5,6]. They contain high levels of crude protein (27.15%), phosphorus (0.76%) and other nutrients [5] while their price is about half to a quarter lower than that of soybean meal and fish meal respectively. Diets containing DDGS does not affect pig growth performance [7,8]. Therefore, pig producers commonly use DDGS to partly replace more expensive dietary protein sources.

In Vietnam, traditional rice distillers' by-product (RDP) is the main co-product after rice fermentation for alcohol production in traditional villages. A considerable amount of RDP is presumed to be produced annually from approximately 20,000 units of traditional alcohol production [9]. For decades, rice distiller's by-product was more commonly used in swine feed and its proportion in pig diet was ordinarily experience-based and fluctuating [10]. Previous research studies [2,10,11] showed that RDP was used as protein and energy source in pig diets because of their cheap cost and frequent availability throughout year. Piglets fed RDP have lower gastrointestinal pH and more *Lactobacillus* sp. than deprived ones, and also less gastrointestinal coliforms [12]. Moreover, use of RDP in pig diets reduces feed cost and enhances economic benefits [2]. However, the studies on the use of RDP as animal feed are still limited. No available data are reported on RDP production, chemical composition and elemental contents, and use in pig diets in Northern Vietnam.

Therefore, the main objective of this research is to provide informations about estimated amounts of RDP obtained in traditional alcohol trade villages of Northern Vietnam, proportion of this by-product in pig diets, and chemical composition and nutritive values of RDP according to storage time. In both farming and scientific research respects, these results will provide more useful information in salvaging RDP as feed for pig production.

2. Materials and Methods

2.1. Research Area and Samples

Three provinces in Northern Vietnam were selected for the study, in which two provinces (Hai Duong and Hung Yen) of the Red River Delta and one province (Bac Giang) of the Northeast. These provinces were selected for this study according the following three norms: (1) the same majority ethnic group Kinh of Vietnam - the focused population, (2) considerable experience making traditional alcohol at different sizes, and (3) existence of animal production. For each province mentioned above, one commune producing alcohol with the highest density (Cam Vu - Hai Duong; Lac Dao - Hung Yen and Van Ha - Bac Giang) was selected by using consultation of local authorities.

A cross-sectional study was randomly conducted from January to August 2015 on 120 rice alcohol producers according to three production scale (L, M and S). Scale-based large, medium and small corresponding to daily alcohol output per household at more than 40 litres, from 20 to 40 litres, and lower than 20 litres, respectively. The sample size according to the scale of alcohol production is showed in the Table 1. Forty households performing both alcohol distillation and animal production were selected by stratified random sampling from each commune.

Table 1. Households distribution by scale of alcohol production and by province

Scale of daily alcohol production	Province			Total by scales
	Hai Duong	Hung Yen	Bac Giang	
Large (> 40 l)	10	10	10	30
Medium (20 - 40 l)	15	15	15	45
Small (< 20 l)	15	15	15	45
Total by provinces	40	40	40	120

2.2. Data collection

2.2.1. Interviews

Data were collected by direct interviews and observations, using a semi-structured interview method with a pre-prepared questionnaire. The questionnaire was previously tested in a total of 9 households (1 household per scale and per commune) before conducting official survey. The questionnaire used in this study was focused on (1) general informations (name and age of householder, family size, number of main active labours, educational level), (2) characteristics of alcohol production (purpose one, experience in making alcohol, input materials used, frequency and amounts of alcohol production, estimates of RDP production), and (3) current use of RDP (as feed for animals, number of pig raised and proportion of RDP in diet of sows and fattening pigs as well as their presumed effects on animal performance in the surveyed households).

2.2.2. Rice distiller's by-product sampling collection

Representative RDP samples were collected directly from the 9 producers chosen for the three different scales of traditional alcohol production in the three study provinces. Three producers of each province by different scales were chosen. Before sampling, tank containing RDP was carefully mixed. In each producer, 7 RDP samples (approximately 500ml per sample) were collected from a single alcohol distillatory batch and stored in plastic bottles, numbered 1 to 7 corresponding to the storage time (day 1 to day 7) and stored under ambient conditions.

2.3. Chemical Composition Analysis of Rice Distiller's By-product

The chemical composition of RDP samples were analysed by AOAC method [13] according to storage time. The pH value was measured using a portable pH-meter (Testo 230, Gemany) in wet form. Dry matter (DM) was determined by oven drying at 70°C for 15h, 90°C for 5h and 102°C for 5h respectively. Crude protein (CP) was determined by the Kjeldahl method (N × 6.25). Ether extract (EE) was determined by the Soxhlet method. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed according to previous study [14]. Gross energy (GE) was measured using E2K-Bomb calorimeter (Germany). Organic acids (lactic acid, acetic acid, butyric acid) were determined by Vinger method [15]. Each RDP sample was analysed in triplicates and calculate the average sample area. For amino acids determination, the RDP at the first day of storage were hydrolyzed by concentrated HCl with phenol at 120°C for 24h. Amino acids were derivatized with OPA and analysed by HPLC (Agilent, USA) with GromSil OPA C18 column, DAD detector, λ absorbance 340 nm. Mobile phase were A: NaH_2PO_4 40 mM, pH 7.8, B: CAN/MeOH/H_2O: 45/45/10, Mobile phase flow rate was 0.05 ml/min, the column temperature was maintained at 30°C.

Six of the nine RDP samples also were analysed for mineral compositon at the first day of storage by AOAC method [13]. Calcium (Ca), phosphorus (P), potassium (K), sodium (Na), magnesium (Mg), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn) were evaluated.

2.4. Statistical Analysis

The data were analysed by using the SAS Software, version 9.4. The general linear model (GLM) was used to measure the effect of scale production level for the survey, while two-way (including the scale production level) chi-square test (χ^2) was used to analyse the qualitative data. For the nutrient composition data, a general linear model including the effect of storage time corrected for the producer effect (considered as random variable) was used.

3. Results

3.1. Characteristics of the Surveyed Households

With respective values close to 4.2 and 2.8 persons, and 49 years old, neither the family size, nor the number of active labours, nor the age of the households differed between the three scales. The experience making traditional alcohol was higher at 30.2 years in L-scale households when compared to 28.8 and 23.7 years at M and S scale respectively. The traditional alcohol production was the main occupation for 100% of the L-scale households, compared to 95.6% and 73.3% at M scale and S scale respectively ($p<0.001$).

3.2. Rice Distiller's by-product Productivity

The productivity of RDP from alcohol production is presented in Table 2. The parameters of RDP were statistically different ($p<0.001$) between the scales.

3.3. Utilisation of Rice Distiller's By-product

The producers used RDP as feed for pigs (100%), chicken (13%) and fish (2,5%). Daily RDP output at least matched for daily pig feeding. Excessive amounts could be stored in jar for feeding animals within three days or sold to other farming villagers.

The number of pig in the surveyed households related significantly to alcohol production scale (Table 3). The number of pigs was significantly different ($p<0.01$) between L, M and S scales. The model of fattening pig raising was popular in most households scales of alcohol production. Mixed breeding concerned around 43, 47, 44% of the surveyed households in L, M and S scales, respectively ($p>0.05$).

The proportion of RDP in swine diets is presented in Table 4. There was not significant difference ($p>0.05$) for the proportion of RDP in sow diets among the three production scales. However, RDP was used at lower proportion for late stage of pregnancy and lactating sows. The proportion of RDP in fattening pig diets decreased from a third to a quarter when turning from the large to the small scale ($p<0.05$).

Table 2. Annual productivity parameters of rice distiller's by-product (LSM±SE)

Variable	Scale of alcohol production			*P*-value
	Large	Medium	Small	
Frequency of alcohol production, time	864^{a}±60.5	682^{ab}±49.4	552^{b}±49.4	<.001
Rice used, ton	20.3^{a}±1.5	12.5^{b}±1.0	8.83^{c}±1.0	<.001
Alcohol production, ton	15.9^{a}±0.7	9.3^{b}±0.6	6.0^{c}±0.6	<.001
Wet RDP, ton	43.7^{a}±2.5	27.1^{b}±2.0	19.4^{c}±2.0	<.001
DM RDP*, ton	4.8^{a}±0.3	3.0^{b}±0.2	2.1^{c}±0.2	<.001

$^{a, b, c}$Value without the same letter in the same row differ significantly ($p<0.05$); RDP: Rice distiller's by-product; *DM of rice distiller's by-product estimated at 11% according to Oanh et al. (2016)

Table 3. Average size of pig number in the surveyed households (head/farmer) during a year

Item	Scale of alcohol production						*P*-value
	Large		Medium		Small		
	n	LSM±SE	n	LSM±SE	n	LSM±SE	
Number of sows	13	3.15^{a}±0.4	21	2.10^{ab}±0.3	20	1.70^{b}±0.3	0.008
Number of growing-fattening pigs	30	66.6^{a}±6.1	44	39.4^{b}±5.3	44	30.1^{c}±5.2	<.001

$^{a, b, c}$Value without the same letter in the same row differ significantly ($p<0.05$); n: number of households raising animal

Table 4. Average proportion in diet of rice distiller's by-product for swine in the surveyed households (% DM)

Item	Scale of alcohol production						*P*-value
	Large		Medium		Small		
	n	LSM±SE	n	LSM±SE	n	LSM±SE	
Sows							
Early stage of pregnancy (0-84 d)	12	28.0±2.8	21	25.4±2.1	19	23.3±2.2	0.431
Late stage of pregnancy (85-114 d)	12	26.1±2.9	16	24.4±2.5	17	22.4±2.4	0.612
Lactation period	10	20.2±1.7	11	19.2±1.7	12	17.9±1.6	0.629
Growing - fattening pigs	30	33.5^{a}±2.3	44	29.3^{ab}±1.7	44	25.3^{b}±1.5	0.011

$^{a, b}$Values without the same letter in the same row differ significantly ($p<0.05$); n: number of households raising animal

3.4. Chemical Composition and Nutritive Value of Rice Distiller's By-product

The chemical composition and nutritive value of RDP are presented in Table 5, Table 6 and Table 7. They were similar ($p>0.05$) among day storage under ambient conditions: pH value ranged from 3.12 to 3.18, with an average value of 3.14; DM content varied from 11.0 to 11.4%, with an average value of 11.1%; CP in RDP DM had an average value of 26.2% and GE had an average value of 20.4 MJ/kg DM. Average nutrient component of RDP DM for EE, Ash, NDF and ADF were 3.68, 5.15, 33.7 and 16.3%, respectively. The lactic acid levels of RDP ranged from 2.2 to 2.38% of wet matter, with an average content of 2.27%. Similarly, the average proportions of acetic and butyric acids were 0.06 and 0.16%, respectively.

The protein quality of RDP distiller's by-product was high when compared to ideal protein (Table 6).

Mineral composition of RDP samples is reported in Table 7. Phosphorus and potassium contents in RDP were higher than that of the other elements. The average iron value was the highest for the trace elements.

Table 5. Daily mean pH, chemical composition and gross energy of rice distiller's by-product during one week storage time

Variable	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	MEAN	SEM	*P*-value
pH	3.14	3.14	3.12	3.15	3.13	3.18	3.15	3.14	0.014	0.992
DM, %	10.97	11.37	11.37	11.15	11.24	11.37	11.02	11.2	0.086	0.981
Composition based on the dry matter, %										
CP	26.37	26.31	25.94	26.72	26.35	25.60	26.24	26.2	0.154	0.998
EE	3.69	3.96	3.47	3.05	3.95	3.89	3.76	3.68	0.175	0.998
Ash	5.14	5.09	5.18	5.14	5.20	4.97	5.33	5.15	0.144	0.984
NDF	34.06	34.67	34.37	33.25	35.32	32.95	31.07	33.7	0.613	0.994
ADF	16.66	16.95	16.79	16.01	17.13	15.56	14.86	16.3	0.474	0.999
GE (MJ/kg DM)	20.34	20.44	20.31	20.11	20.56	20.53	20.60	20.4	0.082	0.089
Composition based on the wet matter, %										
Lactic Acid	2.38	2.30	2.27	2.31	2.28	2.20	2.25	2.27	0.038	0.998
Acetic Acid	0.07	0.05	0.06	0.07	0.08	0.06	0.06	0.06	0.0068	0.819
Butyric Acid	0.12	0.14	0.13	0.18	0.19	0.17	0.16	0.16	0.014	0.816

LSM: Least squares means; SEM: standard error of the mean; CP: crude protein; EE: ether extract; NDF: neutral detergent fiber; ADF: acid detergent fiber; GE: gross energy

Table 6. Comparison of some amino acids in rice distiller's by-product (RDP) from the current study and in dried distillers grains with solubles (DDGS) as reported by litterature

Variable	RDP	DDGS		
		[16]	[17]	[18]
Lys:Lys	100	100	100	100
Thr:Lys	101	72	65	65
Met:Lys	34	63	30	30
Val:Lys	75	75	70	70
Ile:Lys	228	60	60	-
Leu:Lys	123	111	100	101
His:Lys	123	-	32	31
Phe:Lys	186	120	50	54

Table 7. Mineral composition of rice distiller's by-product (RDP) from the current study and of dried distillers grains with solubles (DDGS) as reported by literature

Item	RDP			DDGS					
	Mean	Min	Max	[19]	[4]	[20]	[21]	[5]	[6]
Mineral elements, % DM									
Ca	0.08	0.05	0.10	0.22	0.05	0.29	0.07	0.04	0.08
P	0.75	0.26	1.11	0.83	0.79	0.68	0.77	0.76	0.72
K	0.83	0.39	1.05	0.90	0.84	0.91	0.85	0.91	0.95
Na	0.08	0.04	0.18	0.27	0.21	0.25	0.20	0.17	0.15
Mg	0.30	0.08	0.44	0.20	0.3	0.28	-	-	0.35
Trace elements, ppm DM									
Cu	32.8	9.50	57.9	61.0	5.2	10.0	-	3.86	7.12
Fe	104	23.0	244	276	107	149	-	81.5	125
Mn	64.2	28.1	106	26.0	14.0	22.0	-	10.4	40.9
Zn	88.7	44.0	241	86.0	96.7	61.0	-	57.3	42.0

4. Discussion

4.1. Characteristics of the Surveyed Smallholders

Although parameters such as family size, householder's age or number of labours were similar in levels of alcohol production, higher was the level of alcohol production, more experienced was the producer, as well as more exclusive was his level of occupancy. Thus, level of alcohol production could reflect household's entrepreneurship.

In this research, alcohol producers used sticky brown rice (70%) and regular brown rice (30%). These ingredients were provided from local commerce in the provinces. Yeast used was produced locally at artisan level. Process of traditional alcohol production did not differ from three villages in three province in Northern Vietnam as previously described [22]. Throughout the interviews, study parameters were valorized into estimated figures. As expected, inflows and outflows rates in production chain of alcohol were related to level of production, but to some extent, the steady state of alcohol production efficiency is more surprising, because higher efficiency could have been expected in more industrialised processes.

4.2. Utilisation of Rice Distiller's By-product for Animal in the Surveyed Households

In Vietnam, RDP is highly used as wet feed in pig production. Indeed, this product was saved for pig production by the surveyed households, and to a very low extent for other animals such as chicken and fish, as a result of over production.

Number of sows in large scale households was increased by 1.5 and 1.9 times respectively compared to medium and small scale households. Similarly, number of pigs in large scale households was 1.7 and 2.2 times higher than that of medium and small scales. This correlation appears evident to some extent because pig mainly valorizes RDP from traditional alcohol production.

In this study, pig diets were mainly based on locally available feed sources such as maize, rice, bran, by-products and concentrated or complete feeds. Amounts of RDP obtained were often used extemporarily. Only some households stored them under ambient conditions and used them for a subsequent 3 days maximum.

Proportions of RDP used in sow diets in large scale producers was ordinarily higher, probably owing to dependence on RDP produced when compared to medium and small scale producers. Proportions of RDP used in diets gradually decreased with the stage of gestation and when turning to lactation sows in the three scales. The farmers reported that they experienced lower reproductive performance, i.e., reduced litter size and weight at birth, in so receiving high levels of RDP. This result is consistent with previous report [2] who indicated that litter size and piglet weight at birth were reduced by about 5 and 20% in gestative sows fed diet containing 33% DM RDP in comparison with that deprived of. However, according to [23,24] no effect was observed up to 30% DM RDP in diet. Even more, increased average daily feed intake as well as average daily gain of piglets was observed during lactation [23]. Feeding as high levels of DDGS as 40 to 50% could be reduced sow feed intake and litter performance [24]. Therefore, maternal proportions of RDP observed in this survey could be considered as secure.

Weaned piglet fed diets containing wet wheat distillers grain (WWDG) reduced frequency of diarrhoea compared to piglets fed diet without WWDG [25], likely related to continous supply of lactobacilli. This is consistent with our surveyed results where farmers indicated that RDP in piglet diets was not only effective in reducing feed cost, but also in reducing piglet diarrhoea.

Similarly to sows, feeding of fattening pigs also was based on locally available feed sources. Use of raw materials for formulation was different between alcohol production scales. Proportion of RDP used in fattening pigs also increased linearly from small to large scale as a result of increased RDP produced. Experience-based fattening pig diets containing 25-34% RDP were prefered by farmers. This range was slightly higher than that reported by recent study [10]. The surveyed results indicated that using RDP in fattening pig diet reduced feed cost, improved pig meat owing to higher sensory quality and considered desirable by Vietnamese consumers.

Diet mixture containing up to 30 % rice distiller's by-product did not influence growth performance of fattening pigs [10]. Financial benefits were not increased when pigs were fed diets containing more than 35% dried brewer's grains [26]. Moreover, previous studies [7,8] reported that fattening pig diets containing up to 30% DDGS did not influence carcass characteristics and meat quality parameters of *Longissimus dorsi* muscle.

Indeed, surveyed results on the effects of RDP in pig diet are consistent with previous reports on animal performance and meat quality. However, effects of RDP on slaughter yield, carcass characteristics and meat quality parameters ought to be done in order to confirm the results of the present study.

4.3. Nutritional Value of Rice Distiller's By-products

The chemical and nutrient parameters measured over 7 days of conservation under ambient temperature were stable. The present results indicated consistency within uniformity between the three different levels of traditional alcohol production.

The average dry matter content was slightly higher than that from previous studies [2,10]. This inconsistency could be explained by the difference in proportion between rice and water, and perhaps of the fermentation process which influences capacity of starch removal.

The average crude protein level in RDP was in line with values reported previously [2,10]. However, a recent finding [11] showed that most amino acid levels in RDP of the present study were higher than those from previous reports [2,10]. This could be explained by some differences in non protein nitrogen owing to fermentation technology or rice varieties, as well as by analysis method. The indispensable amino acids for pigs include histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. They play an important

role in physiological functions as well as growth and development of pig's body. Lysine is considered as the first limiting amino acid for growth in pigs, therefore, requirement of other amino acids is frequently reported to lysine requirement. The result of this work indicated that sulphur amino acids levels in RDP were higher than that of ideal protein of previous studies [16,17,18]. The relative levels of the three branched chain amino acids (Leu, Ile, Val) were high, especially for Ile which could be considered as profitable for meat production and pig immunity owing to specific roles of these amino acids in that metabolisms [27]. Finally, high crude protein and amino acid levels in RDP could thus help to replace expensive protein sources as fishmeal or soybean meal for swine.

The average EE content in RDP was lower than 9.9% presented by previous study [2] and also than crude fat of DDGS reported in NRC [19]. The average ash content of RDP (5.15%) was within the range of values (2.2 to 8.5%) in RDP studied by [2].

In this study, NDF level in RDP was high and could provide an advantage in digestive energy and metabolisable energy [4]. When considering fibers, NDF and ADF contents in RDP were higher than that reported by previous work [2] and similar to NDF (34.6%) and ADF (16.3%) values in the DDGS [19]. The RDP in the present study appeared to contain a similar proportion of structural fibers as hemicellulose. Soluble fiber content with low molecular weight could not be determined. However, RDP presumably has a diversified fibers profile which could contribute to enhance health of intestinal microbiota.

Difference among chemical composition of RDP in the present study when compared to previous studies is probably ascribed, as for DDGS, by input materials, distillation equipment and production process [4,5].

During 7 days of conservation under ambient conditions, pH value of RDP was stable around 3.14 which is within the range of values (2.98 to 3.43) in RDP indicated by previous finding [2]. Low pH value of RDP is a favorable element in reducing pH value and in increasing counts of lactic acid bacteria in digestive tract of pigs [28]. Similarly, there was no significant difference in the contents of organic acids during storage time. Level of lactic acid was meaningfully higher than levels of acetic acid and butyric acid, possibly caused by typical yeast metabolism. In pig diet, lactic acid reduces gastric pH and delays multiplication of enterotoxigenic *Escherichia coli* [29]. In piglet digestive tract, diets containing RDP help to reduce *E.coli* and total coliform numbers, beneficially to lactic acid bacteria [12]. Events of diarrhoea are also reduced in piglets fed WWDG [25]. Therefore, the nutritive values of RDP kept constant over a week. Thus, fresh RDP for swine feeding presumably can be stored for at least one week - instead of 3 days as classically assessed by farmers.

According to previous study [30], the elemental contents (/kg DM) of Vietnamese brown rice is about 0.13 g calcium, 3.200 g phosphorus, 5.2 mg copper, 12 mg iron, 24 mg manganese and 27 mg zinc. During the process of alcohol production, approximately two thirds of grains is converted into alcohol and carbon dioxide, increasing thus 3-folds concentrations of unfermented remaining nutriments [4,20]. Thus, the average values of calcium, phosphorus, copper, iron, manganese and zinc in RDP of present study are increased between 2 and 9 times in comparison with value of brown rice. The results of this study are in agreement with previous studies [4,5,6,21] who indicated that most mineral contents of DDGS are at least 3 times higher than those of the grain from which it originated. In the present study, average phosphorus content in the rice distiller's by-product samples analysed was within the range of published values in DDGS of previous reports [4,5,6,19,20,21]. Calcium level in RDP was lower than in DDGS as reported by previous studies [19,20] or slightly higher [4,5]. Sodium content in RDP was lower than in DDGS of previous results [4,5,19,20,21]. Copper and iron contents in RDP was higher than values in DDGS of recent reports [4,5,20] and slightly lower than indicated by NRC [19]. Similarly, previous studies [5,19,20] reported lower manganese and zinc contents in DDGS when compared to our data. Such inconsistencies could be explained by ecological rice production parameters, distillate equipment, yeast generation and alcohol production process, as stated by different studies [4,5,21]. Thus, using RDP in pig diets could help fulfilling mineral requirements and improve animal health and performance.

5. Conclusions

Important amounts of rice distiller's by-product are annually produced by alcohol manufacturers in villages of traditional alcohol production, and consequently used for swine farming, especially for fattening pigs, and to a lower extent in females with high needs. Rice distiller's by-product is acidic and thus nutritionally stable and, on a dry matter basis, rich in high quality crude protein and fermentable fibres. Use of rice distiller's by-product can help to meet significant feed requirement for animal production in the current context of Vietnam.

Further researches are needed to determine digestibility of rice distiller's by-product in Vietnam, and its effects on animal performance, health and gut microflora of pigs.

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