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Nutrient analysis of common local feed ingredients used by swine farmers in Cambodia

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Abstract

Nutrient analysis of common local feed ingredients for swine was conducted on rural and peri-urban smallholder farms in USAID Feed-the-Future (FtF) zones of influence in Cambodia, which includes the provinces of Battambang, Siem Reap, and Kampong Thom. Feed ingredient collection was completed in the early dry, early rainy, and late rainy seasons (December 2017, May 2018, and August 2018 respectively). In each period, feedstuffs were collected as available from smallholder farmers and feed stores. In total, 305 ingredient and complete feed samples from 225 smallholder pig farms and stores were collected. Of these, 24 ingredient types were present and 72 of the 305 samples were sub-selected and analyzed for the nutrient contents. Rice bran and other rice-based ingredients were the most common energy feed ingredients found, are widely used for feeding pigs in Cambodia, but had variable chemical composition. The crude protein (CP) content of different rice brans ranged from 7.3 to 13.2% on a dry matter (DM) basis, with a majority of rice bran samples collected being lower quality with low CP and high fiber content. While soybean meal was shown to be an excellent source of CP, it was rarely found on farms or in feed stores in these provinces. Dried fish head and dried shrimp head are also rich in CP, calcium, and phosphorus, and was used as a protein ingredient for feeding pigs but it was not available in the large quantities. Morning glory (*I. Aquatica*) is mainly used as a leguminous plant for feeding and has a high CP content on a DM basis (21.4%) but was low in DM content. Another commonly found local ingredient, banana trunk, had the lowest nutritional value being very high in crude fiber. In conclusion, understanding the nutrient content of local feed ingredients used by smallholder swine farmers can improve pig diets and provide an opportunity for increased economic efficiency for swine farmers.

Keywords: *chemical analysis, feedstuffs, rice bran, smallholder farmer, swine*

Introduction

In Cambodia, pig production contributes to household income of smallholder farmers and provides local food security (Samkol et al 2006, Seré et al 1995). There are three major types of pig production: 1) smallholder, 2) semi-commercial, and 3) commercial production. Of these production types, the largest percentage, roughly 80%, are smallholders (FAO 2011; Sovann and Sorn 2002). Disease outbreaks are considered one of the main constraints, along with expensive feed and low payment prices for the slaughter pigs (Ström et al 2017). Feed availability and cost are major limiting factors for most smallholder pig farmers and contributes up 60 to 70% of the total cost of pig production (FAO 2011). Many smallholder farmers utilize local materials and/or left-over food as feed. Farmers may purchase a low-cost ingredient, such as rice bran, but often feed it without sufficient protein or vitamin and mineral supplementation (Sokchea et al 2018b). Although this approach can be effective to sustain pigs, it does not optimize pig nutrition and subsequently production. Pig health can be compromised by pig scavenging or the feeding of low-quality feed sources. Therefore, improvements to on-farm pig nutrition programs can produce considerable benefits for smallholder farmers, including reduced morbidity and mortality, and increased income and return on investments.

There are numerous feed ingredients that can be available for pigs. Locally available feed ingredients can reduce diet cost and increase economic efficiency by reducing the pressure on using imported ingredients (Stein et al 2016; Kinh et al 2014). Nutrient analysis of different feed ingredients is necessary for researchers, but also for animal producers, who can use these chemical values for accurate formulation of pig diets (Kinh et al 2014). In addition, protein, vitamins, and mineral are often supplied under the nutrient requirements of the pigs. Locally available ingredients, such as green plants, can be used to improve the nutritional status of local pigs at low cost (Chittavong et al 2012). Pigs often are fed cereal grain for their main source of energy, and certain stages of growth as much as 90% of their diet may consist of cereals and cereal by-products (McDonald et al 2002). The net energy content of these ingredients can be estimated from chemical composition through net energy prediction equations (Liu et al 2015). However, information on the chemical composition and value of local feed ingredients for pigs in Cambodia is inadequate and limited. Thus, the objective of this study was to collect locally available feed ingredients being used by pig farmers and determine their nutrient content.

Material and methods

Study area

The study focused mainly on rural and peri-urban smallholder famers in United States Agency for International Development (USAID) Feed-the-Future (FtF) zones of influence in Cambodia, which includes the provinces of Battambang, Siem Reap, and Kampong Thom. These provinces are located around Tonle Sap Lake, Cambodia. The selection of the study site was based on the number of smallholder farms and density of pig population from the report of the Provincial Department of Agriculture, Forestry and Fishery; and District Department of Animal Production and Health in Cambodia. These areas include two districts in Kampong Thom, three districts in Siem Reap, and three districts in Battambang province. According to Thoeun (2015), the climate in the regions is governed by monsoon and divided into two regular seasons with a dry season from November until April and a wet season from May to October. Annual rainfall ranges from 1,400 to 4,000 mm and the average annual temperature is 28°C with the average maximum temperature of 38°C in April, and average minimum temperature of 17 °C in January.

Sample and sampling methods

Feed ingredient collection was divided into three different time periods; in the early dry, early rainy, and late rainy seasons (December 2017, May 2018, and August 2018 respectively). Smallholder pig producers and feed store owners in target provinces were briefly interviewed about feedstuffs and feed resources used for pig feeds. Feed ingredient samples were collected during these interviews based on their availability and use. Ingredients were split into three categories: dried, fresh, and liquid form. For dried ingredients, 100 g samples were obtained. For fresh and liquid ingredients, 500 g samples were placed in pasteurized plastic bags. After collecting, liquid and fresh samples were instantly stored on ice and transported to the Graduate School-Chemical Analysis Laboratory at Royal University of Agriculture, Phnom Penh for further analysis. Dried feed ingredients were placed in plastic bags and transported to the same laboratory. In each collecting period, feed ingredients were collected as available from smallholder farmers and feed stores. After completion of sample collection, a subset of ingredients was selected for chemical composition analysis. The selected ingredient samples were obtained according to the frequency and similarity of samples used by farmers and sold by feed stores in the regions. In total, 305 ingredient and complete feed samples from 225 smallholder pig producers and stores were collected. Of these, 24 ingredient types were present and 72 of the 305 samples were sub-selected and analyzed in the nutrient contents (Table 1).

Chemical analysis

Feed ingredient samples were analyzed for dry matter (DM; AOAC 934.01, 1990). Ash analysis was described by AOAC (1990) with method code (942.05). Calcium (Ca) and phosphorus (P) were analyzed as described by AOAC (2006). Crude protein (CP) and nitrogen were determined by Leco FP-528 (LECO Corporation, ISO-9001:2008, USA, 2014). Ether extract (EE) was determined by ST243 SoxtecTM Extraction Unit (Foss Analytical Co., Ltd, China, 2014). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and crude fiber (CF) were determined by ANKOM 200i, approved procedure by AOCS (ANKOM Technology, USA).

Statistical analysis

Data on chemical composition of feed ingredients were analyzed using one-way Analysis of Variance (ANOVA) with PASW Statistics 18 for the description of means and standard deviation.

Table 1. Chemical composition of local feed ingredients used for pig feed in Battambang, Siem Reap and Kampong Thom provinces (%, DM basis, Mean ± Std)

	N	DM	CP	CF	Ash	EE	ADF	NDF	P	Ca
Energy ingredients										
Rice products										
Broken Rice	8	90.51 ±2.17	7.48 ±1.29	1.23 ±1.46	0.85 ±0.37	0.67 ±0.24	2.08 ±1.54	3.53 ±2.22	0.12 ±0.009	0.016 ±0.011
Dried cooking rice	3	88.40 ±1.49	6.64 ±0.34	0.44 ±0.06	0.35 ±0.13	0.11 ±0.07	1.07 ±0.31	1.51 ±0.49	0.09 ±0.01	0.02 ±0.010
Paddy rice	2	89.66 ±1.70	6.66 ±0.26	11.85 ±0.58	4.21 ±0.18	1.24 ±0.93	15.08 ±0.96	16.88 ±1.95	0.27 ±0.056	0.04 ±0.021
Rice bran grade 1	3	91.81 ±0.23	13.20 ±0.58	15.57 ±7.01	11.79 ±1.58	9.72 ±6.44	22.68 ±8.50	30.22 ±10.61	1.23 ±0.59	0.37 ±0.25
Rice bran grade 2	3	92.39 ±0.26	10.86 ±0.43	15.31 ±0.87	10.96 ±1.18	11.91 ±0.91	22.21 ±2.96	32.50 ±1.81	1.40 ±0.03	0.06 ±0.01
Rice bran grade 3	16	92.61 ±1.81	7.32 ±0.90	26.22 ±3.58	14.28 ±2.79	6.33 ±1.52	39.41 ±5.71	47.59 ±6.96	0.77 ±0.20	0.06 ±0.020
Rice bran (mixed)	4	91.59 ±0.38	10.41 ±1.44	8.76 ±3.94	7.25 ±1.98	8.99 ±3.02	12.25 ±4.78	17.90 ±5.62	0.98 ±0.334	0.19 ±0.295
Dried cassava chip	1	88.82	2.02	4.41	5.44	0.20	8.63	9.81	0.08	0.33
Maize grain	2	90.01 ±1.25	8.64 ±0.45	3.14 ±0.65	1.63 ±0.28	3.29 ±1.19	3.81 ±0.51	11.23 ±2.28	0.26 ±0.021	0.02 ±0.014
Protein ingredients										
Dried crawfish head	1	88.92	43.63	10.26	30.38	4.16	14.14	24.73	1.50	5.58
Dried fish head	1	92.13	40.99	1.14	31.72	22.88	1.27	4.11	3.35	5.90
Soybean meal	2	87.46 ±1.97	50.29 ±0.79	4.13 ±0.63	7.56 ±0.06	1.37 ±0.04	6.21 ±1.03	9.06 ±0.19	0.81 ±0.113	0.33 ±0.028
Plants and forages ingredients										
Banana trunk (*Musa balbisiana*)	4	6.72 ±2.51	3.12 ±0.86	29.89 ±4.24	14.11 ±7.71	0.65 ±0.30	34.25 ±4.72	47.28 ±5.56	0.19 ±0.201	0.47 ±0.059
Morning glory (*Ipomoea aquatica)*	11	9.13 ±1.69	21.42 ±5.83	16.46 ±1.72	16.65 ±2.81	1.41 ±0.45	26.38 ±2.69	29.83 ±2.68	0.58 ±0.283	0.67 ±0.285
Amaranth spinosus L.	1	11.45	22.39	18.45	22.11	1.18	23.02	33.35	0.54	0.91
Sweet potato vine *Ipomoea batatas.L*	1	11.03	20.10	16.49	13.55	2.27	23.02	25.40	0.44	0.47
Taro leaves with petiole	1	6.25	14.47	17.04	18.58	1.13	26.12	27.32	0.66	0.93
Water mimosa *Neptunia oleracea*	1	15.53	22.18	19.64	7.44	1.32	33.00	33.39	0.37	0.58
Other ingredients										
Banana trunk with rice bran	1	6.36	7.82	26.91	17.46	0.28	31.24	45.19	0.14	0.45
Fish head (mixed)	1	41.55	36.59	2.30	32.16	23.08	2.80	8.74	1.22	2.03
Freshwater fish head (cooked)	1	22.74	15.33	1.65	7.38	6.58	2.29	3.42	0.96	1.56
Khmer noodle	2	12.91 ±0.19	4.98 ±1.15	0.61 ±0.07	0.54 ±0.54	0.06 ±0.04	1.53 ±0.04	1.77 ±0.06	0.07 ±0.028	0.03 ±0.007
Residual Cabbage	1	6.64	27.95	14.39	10.97	0.99	17.00	22.01	0.60	0.84
Rice liquor	1	12.10	20.27	9.32	7.03	7.11	14.75	17.88	0.68	0.11

N=Number of Sample, DM=Dry Matter, CP=Crude Protein, CF=Crude Fiber, EE=Ether Extract, ADF=Acid Detergent Fiber, NDF=Neutral Detergent Fiber, P=Phosphorus, Ca=Calcium

Results and discussions

Energy feed ingredients

Rice products

Rice bran and other rice-based ingredients were the most common energy ingredients found on farms during the study (Table 1) with maize and cassava samples to a lesser extent. Broken rice is the remaining rice fragment from the rice milling processing and was used by several farmers. The broken rice was low in CP, which was supported from reports by Chittavong et al (2012); Chhay Ty and Preston (2005); and Huyen et al (2013). The nutrient component of broken rice and dried cooking rice had similar profiles being lower in CP, CF, ash, and ether extract which indicates the hull was removed. However, paddy rice was much higher in CF, ADF, and NDF indicating the rice hull was still present. Paddy rice is ground for swine feed when its price is low. The CP content of paddy rice in this study was similar to that reported by Huyen et al (2013) and Tam et al (2009) and had a lower CP and CF level than rice bran tested in this study.

Rice bran was the most commonly found swine feed ingredient on swine farms and in feed stores. 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 (Samkol et al 2006). Some higher quality rice brans were found, but the majority of the rice bran samples collected were lower quality with low CP and very high fiber content. Rice bran quality in the study area is classified into three grades. The rice bran grade 1 was higher in CP and P content, which was supported by Li Thi Men et al (2010), than rice bran grade 2 and 3. Rice bran grade 3 had the lowest nutritive quality for swine, which is in agreement with Samkol et al (2006). Also, Rice bran grade 3 had a similar CP compared to broken rice but was much higher in fiber. The increased concentration of rice husk in rice bran is associated with the higher levels of CF, ADF, and NDF and lower CP, and consequentially results in poorer quality rice bran for swine. The mixed rice bran is the combination of rice bran with whole rice which was a similar CP content as the rice bran grade 2, but with much lower fiber, ash, ADF, and NDF than the three quality grades of rice bran. Rice bran grade #1, the highest quality rice bran, had 12 to 13% CP and the poorest quality rice bran, grade 3, had the lowest CP ranging from 8 to 10%. The rice hull or husk is high in fiber which pigs digest poorly. Thus, rice bran with high level of hulls is an indication of poorer quality feeds (Samkol et al 2006).

Dried cassava chip

As the second largest crop production after rice in Cambodia, cassava (*Manihot esculenta crantz*) is mainly cultivated by smallholder farmers for consumption, animal feed, and starch extraction of its root, but exportation as fresh root to the international market is the main destination (MAFF 2015). Cassava root is one of the potential energy feed ingredients and animal feed resources in Cambodia, but cassava root has had limited use by small-scale farmers for feeding pigs. In the present study, only one sample of dried cassava chip was found on farm and it had a low CP, EE, and P content but was higher in CF, ash, ADF, NDF, and Ca when compared to broken rice. The analyzed CP, ash, and fiber content in this present study was similar to that reported by Hang Du Thanh et al (2009).

Maize

Although maize is one of the main grain sources used for pigs in many countries, only two samples of maize grain were found in the present study. The analyzed values showed it was higher in CP, EE, and fiber concentrations than broken rice. The nutrient of maize grain this study was in agreement with the analysis reported by Kinh et al (2014) and Liu et al (2015).

Protein feed ingredients

Soybean meal

Even though soybean meal is widely used as a major protein source for animal feed worldwide, smallholder pig producers in Kampong Thom, Siem Reap, and Battambang rarely use soybean meal for feeding their pigs. Reasons could possibly be the lack of information about use in animal feed, farmers not realizing the advantage of soybean meal in pig feed, or because of availability of soybean meal in the regions. Soybean meal was only found on two farms. Chemical composition indicated that the DM and EE of soybean meal in this current study was similar to previous studies by Harlıoğlu (2012) and Li Thi Men et al (2010), but CP was higher than in those previous studies. Fiber and ash content were also in agreement with Harlıoğlu (2012), but lower than the analysis result from Li Thi Men et al (2010). Soybean meal has variation in nutrient composition due to several factors, such as the origins and source of soybean, nature of oil extraction process, and manufacturing technique. While soybean meal is generally consistent in nutrient composition, Thakur and Hurburgh (2007) showed that the soybean meal from Brazil was higher in CP than soybean meal from US and other regions, but the percentage of total digestible amino acids was highest for SBM from the US and China.

Dried fish heads

Fresh water fish is one of the most important protein sources for the people of Cambodia. As the main dish, fish are processed to other human edible products, such as smoked fish, grilled fish, and fermented fish, to preserve for long term consumption. The unused by-products from these processes, such as fish heads, are sundried to be used as an animal feedstuff. Dried fish heads are available and are used for feeding pigs. The chemical analysis of dried fish head showed them to be an excellent source of CP, Ca, and P, but highly variable and not available in the large quantities for feeding. According to the study of Thuy et al (2010), the DM, CP, and EE content of catfish by-product was 43.5, 37.7 and 19.4%, respectively, on a DM basis, which were different from the nutritive value of this present study and also differed from fish meal (90.1, 51.5 and 8.3%, respectively). The fish type, by-product input material, and fat extraction procedure for catfish by-product could explain the variation between sources of fish by-products such as fish heads.

Plant and forage feed ingredients

Banana trunk (Musa balbisiana)

Banana is widely cultivated or grown wildly throughout Cambodia, and pig raisers generally use the trunk for feeding animals, especially feeding local pigs. Ngo Huu Toan and Preston (2007) stated that poorer farmers were the more intensive users of feedstuffs such as banana trunk compared to medium-sized pig producers. Banana trunk in this present study was found to be lowest in CP and EE and highest in CF compared to all other ingredients collected and analyzed. This is an indication that banana trunk was the poorest quality feedstuff that was found on swine producer farms. When comparing to other published values, Sokchea et al (2018a) showed that the DM, CP and fiber content was 7.02, 6.42 and 32.64% on a DM basis, respectively, which are relatively similar to the values for banana trunk in the present study. The nutrient profile of banana trunk can vary based on the banana variety and cutting time prior to feeding. The banana trunks that were collected in the study areas were wild types in the *Musa balbisian* species, which were brought into the region and in many cases planted around the pig barns.

Morning Glory (Ipomoea aquatica)

Morning glory or water spinach can be used as a fresh plant for feeding pigs. Morning glory was grown throughout the research location and is often cultivated near pig barns, farm houses, and other locations of water pools. Morning glory had a very low DM content due to harvest while in a growing

stage. It is often supplied in combination with other grains and protein sources for pigs. Morning glory had a high CP content on a DM basis (21.4%), being similar to the CP content of amaranths; however, DM content was only 9.1%. The CP content of morning glory ranged from 20 to 31.1% on a DM basis in previous studies (Chittavong and Preston 2006; Phiny et al 2008; Li Thi Men et al 2010; Nakkitset et al 2008; Dung et al 2002; Chhay Ty et al 2007). The wide variation in nutrient composition of morning glory is not unexpected due to differences in harvesting and cutting stage, fertilization, soil type, or variety of morning glory cultivar.

Other plants and forages

Similar to banana trunk and morning glory, other plants and forages are generally lower in DM and EE and higher in fiber content compared to other energy and protein sources for swine farmers. These plants and forages are often locally found in areas surrounding the pig farmers or on their farms directly. Thus, they provide readily available and economical source of nutrients, but must be fed with other feedstuffs to adequately balance the pigs' daily diet. The high-water content limits their use as a nutrient source. The nutrient profile of these feedstuffs can vary widely depending on the amount of stem and leaves harvested together.

Conclusion

- The chemical composition of local pig feed ingredients in this study indicated that a wide range of ingredients were used, and those ingredients vary in availability and nutrient composition.
- As expected, rice bran was the most used feed ingredient and its composition varied dramatically.
- Swine farmers need to identify quality differences of the various ingredients they feed to improve the nutrition and economics of their pigs.

Acknowledgement

This work was funded in whole or part by the United States Agency for International Development (USAID) Bureau for Food Security under Agreements # AID-EEP-A-00-09-00004 and AID-OAA-L-15-00003 as part of Feed the Future Innovation Lab for Horticulture and Feed the Future Innovation Lab for Livestock Systems. Any opinions, findings, conclusions, or recommendations expressed here are those of the authors alone. We are also thankful to the local authorities, farmers, and the feed store owners which collaborated with us; and junior students from the Faculty of Veterinary Medicine, Royal University of Agriculture which contributed in the sample collecting at field and helped in the analysis.

References

AOAC 1990 Official methods of analysis. 15th Edition. Association of Official Analysis Chemists, Arlington.

AOAC 2006 Official methods of analysis. 18th Edition. Association of Official Analysis Chemists, Arlington.

Chhay Ty and Preston T R 2005 Effect of water spinach and fresh cassava leaves on growth performance of pigs fed a basal diet of broken rice. Livestock Research for Rural Development. Volume 17, Article #76. Retrieved February 8, 2019, from http://www.lrrd.org/lrrd17/7/chha17076.htm

Chhay Ty, Borin K and Preston T R 2007 Effect of mixtures of water spinach and fresh water hyacinth leaves on growth performance of pigs fed a basal diet of rice bran and cassava root meal. Livestock Research for Rural Development. Volume 19, Article #194. Retrieved September 2, 2019, from http://www.lrrd.org/lrrd19/12/chha19194.htm

Chittavong M and Preston T R 2006 Intake and digestibility by pigs fed different levels of sweet potato leaves and water spinach as supplements to a mixture of rice bran and cassava root meal. Livestock Research for Rural Development. Volume 18, Article #86. Retrieved September 2, 2019, from http://www.lrrd.org/lrrd18/6/mala18086.htm

Chittavong M, Lindberg J E and Jansson A 2012 Feeding regime and management of local Lao pigs in Central Lao PDR. Tropical Animal Health and Production, 45(1), 149-155, https://doi.org/10.1007/s11250-012-0186-1

Dung N N X, Manh L H and Udén P 2002 Tropical fibre sources for pigs—digestibility, digesta retention and estimation of fibre digestibility in vitro. Animal Feed Science and Technology, 102(1-4), 109-124. https://doi.org/10.1016/S0377-8401(02)00253-5

Food and Agriculture Organization of the United Nation (FAO) 2011 Rome. Pigs for Prosperity. Retrieved May 7 2020 from http://www.fao.org/3/i2471e/i2471e00.pdf

Hang Du Thanh, Linh Nguyen Quang, Everts H and Beynen A C 2009 Ileal and total tract digestibility in growing pigs fed cassava root meal and rice bran with inclusion of cassava leaves, sweed potato vine, duckweed and stylosanthes foliage. Livestock Research for Rural Development. Volume 21, Article #12. Retrieved September 2, 2019, from http://www.lrrd.org/lrrd21/1/hang21012.htm

Harlıoğlu A G 2012 Effect of solvent extracted soybean meal and full-fat soya on the protein and amino acid digestibility and body amino acid composition in rainbow trout (Oncorhynchus mykiss). Iranian Journal of Fisheries Sciences, 11(3), 504-517.

Huyen N T D, Trach N X and Preston T R 2013 Effects of supplementation of paddy rice and/or rice grain and/or rice husk to sweet potato (Ipomoea batatas) vines as basal diet on growth performance and diet digestibility in rabbits. Livestock Research for Rural Development. Volume 25, Article #19. Retrieved September 2, 2019, from http://www.lrrd.org/lrrd25/1/huye25019.htm

Kinh L V, Viet T Q, Trung V N, Cai V D and Van N T 2014 Nutrition, feeds and feeding for pig production in Vietnam: Current status and future research–A review. pp 35-36, https://cgspace.cgiar.org/bitstream/handle/10568/72676/VN_feeds_review_apr2014.pdf?sequence=1

Li Thi Men, Ogle B, Son V V and Preston T R 2010 Evaluation of water spinach (Ipomoea aquatica) as a protein source for Ba Xu yen and Large White sows. Livestock Research for Rural Development. Volume 22, Article #70. Retrieved February 4, 2019, from http://www.lrrd.org/lrrd22/4/leme22070.htm

Liu D W, Liu L, Li D F and Wang F L 2015 Determination and prediction of the net energy content of seven feed ingredients fed to growing pigs based on chemical composition. Animal Production Science, 55(9), 1152–1163, https://doi.org/10.1071/AN14091

McDonald P, Edwards R A, Greenhalgh J F D, Morgan C A, Sinclair L A, and Wilkinson R G 2002 Animal Nutrition, 7th Edition, pp 542-543

Ministry of Agriculture, Forestry and Fisheries (MAFF) 2015 Strategic Planning Framework for Livestock Development: 2016-2025: "A Future Direction for Livestock Development in Cambodia". pp. 4-5

Nakkitset S, Mikled C and Ledin I 2008 Effect of feeding head lettuce, water spinach, ruzi grass or Mimosa pigra on feed intake, digestibility and growth in rabbits. Asian-Australasian Journal of Animal Sciences, 21(8), 1171-1177, https://doi.org/10.5713/ajas.2008.70628

Ngo Huu Toan and Preston T R 2007 Evaluation of uncultivated vegetables for pigs kept in upland households. Livestock Research for Rural Development. Volume 19, Article #150. Retrieved September 2, 2019, from http://www.lrrd.org/lrrd19/10/toan19150.htm

Phiny C, Ogle B, Preston T R and Borin K 2008 Growth performance of pigs fed water spinach or water spinach mixed with mulberry leaves, as protein sources in basal diets of cassava root meal plus rice bran or sugar palm syrup plus broken rice. Livestock Research for Rural Development. Volume 20, supplement. Retrieved September 2, 2019, from http://www.lrrd.org/lrrd20/supplement/phin2.htm

Samkol P, Borin K and Sovann S 2006 Pig systems in Southeast Asia-the case of Cambodia. Pig systems in Asia and the Pacific: how can research and development enhance benefits to the poor, 34-42, https://www.researchgate.net/publication/262840137

Seré C, Steinfeld H and Groenewold J 1995 World livestock production systems: current status, issues and trends. In Consultation on Global Agenda for Livestock Research, Nairobi (Kenya), 18-20 Jan 1995. ILRI. pp 37-38

Sokchea H, Thu Hong T T, Ngoan L D, Phung L D and Borin K 2018a Nutritive Value of Fermented Banana Pseudo Stem (Musa spp) and Rice Bran by Saccharomyces cerevisiae. International Journal of Agriculture Innovations and Research. Volume 7, Issue 2, ISSN (Online) 2319-1473

Sokchea H, Thu Hong T T, Ngoan L D and Borin K 2018b Pig Production System of Ethnic Group in Ratanakiri. Journal of Veterinary and Animal Research, 1(1), pp 103, https://doi.org/10.18875/2639-7315.1.103

Sovann S and Sorn S 2002 Pig Production in Cambodia: in Priorities for Pig Research in Southeast Asia and the Pacific to 2010, ACIAR (2002), pp 22-27

Stein H H, Lagos L V and Casas G A 2016 Nutritional value of feed ingredients of plant origin fed to pigs. Animal Feed Science and Technology, https://doi.org/10.1016/j.anifeedsci.2016.05.003

Ström G, Andersson Djurfeldt A, Boqvist S, Albihn A, Sokerya S, San S, Holl Davun and Ulf Magnusson 2017 Urban and peri-urban family-based pig-keeping in Cambodia: Characteristics, management and perceived benefits and constraints. PLoS ONE 12 (8): e0182247, https://doi.org/10.1371/journal.pone.0182247

Tam N H, Tuan V T, Lam V, Hang B P T and Preston T R 2009 Effects on growth of rabbits of supplementing a basal diet of water spinach (*Ipomoea aquatica*) with vegetable wastes and paddy rice. Livestock Research for Rural Development. Volume 21, Article #174. Retrieved May 7, 2020, from http://www.lrrd.org/lrrd21/10/hang21174.htm

Thakur M and Hurburgh C R 2007 Quality of US soybean meal compared to the quality of soybean meal from other origins. Journal of the American Oil Chemists' Society, 84(9), 835-843, https://doi.org/10.1007/s11746-007-1107-8

Thoeun Heng Chan 2015 Observed and projected changes in temperature and rainfall in Cambodia, Climate Change Department, Ministry of Environment, Cambodia, Weather and Climate Extremes, Vol.7, pp 61–71, https://doi.org/10.1016/j.wace.2015.02.001

Thuy N T, Lindberg J E and Ogle B 2010 Digestibility and nitrogen balance of diets that include marine fish meal, catfish (*Pangasius hypophthalmus*) by-product meal and silage, and processing waste water in growing pig. Asian-Australasian Journal of Animal Sciences. Vol. 23, No. 7: 924-930, https://doi.org/10.5713/ajas.2010.90496

Received 11 May 2020; Accepted 11 May 2020; Published 1 July 2020

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