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Effect of Fermented Kepok Banana Corm Inclusion in the Diet on the Nutrient Digestibility and Mineral Ca and P Retention of Growing Pigs

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Abstract: Sixteen crossbred growing pigs *Duroc x Landrace*, (10 weeks of age; initial body weight 27 ± 3.92 kg) were allotted into four treatments in a randomized block design to evaluate the effects of inclusion of fermented kepok banana corm (FKBC) in the diet on the nutrient digestibility and mineral Ca and P retention of growing pigs. There were four treatments diets offered: basal diets without FKBC (R0); basal diets + 7% FKBC (R1); basal diets + 14% FKBC (R2); basal diets + 21% FKBC (R3). Results of the study showed that inclusion of 21% FKBC in the diet of pigs significantly reduced ($P < 0.01$) dry matter intake compared to the control diet. There were no significant difference between 14% and 21% FKBC on the intake and digestibility of dry matter of the pigs. However, inclusion of FKBC at the level of 7% showed the optimum digestibility of dry matter, crude protein, and energy with the average value of 66.57%, 83.43% and 70.76%, respectively. In addition, mineral consumption and retention of Ca and P were 14.30 and 9.10 g/day, respectively with the value of mineral retention both Ca and P were 11.90 and 7.50 g/day, respectively. It can be concluded that inclusion of FKBC at the level of 7% increased dry matter digestibility and energy.

Keywords: Corm, Fermented, Nutrient Digestibility, Mineral Retention, Growing Pig

1. Introduction

Pig production in East Nusa Tenggara (ENT) Province, Indonesia is not only to fulfil meat demands, it also uses as savings, as social status and for religious ceremonies, respectively [1]. The ENT pig population is estimated at ± 1.70 million [2], with ± 85% being owned by smallholder farmers [3]. Pig demand in ENT was 1,134,552 animals per year and pork are a critical source of protein for domestic consumption where about 90% of the population of 5 million are non-Muslim and considered as pork eaters [1]. However, pig production in this area is still low due to the insufficient of feed both quantity and quality [4]. In addition, most of raw materials used in the feed industry such as corn and wheat are imported, and consequently resulting in the increase of cost production [5]. The utilization of local feed from agricultural by products, on the other hand, are less desirable due to its low nutrients quality. Alternatively, processing such products that locally available through fermentation by utilizing yeast (*Saccharomyces cerevisiae*) and fungus (*Aspergillus niger*) prior to offered to animal as source of feed is necessarily important.

Kepok banana corm (*Musa paradisiaca*) or locally known as fried banana (plantain banana) is usually left in the farm after harvesting the banana fruits and it classified as waste, with its potential production about 40% [6]. The kepok banana corm utilization as feed sources for livestock, however, is still constrained by the presence of high crude fiber, complex carbohydrates and antinutrition. It has been reported that the starch composed of amylose and amylopectin, which would be hard to be digested by digestive enzymes [7]. Therefore, complex molecules of starch of kepok banana corm is expected to reduce, through

fermentation since yeast (*Saccharomyces cerevisiae*) and fungus (*Aspergillus niger*) contained some enzymes that can broke down the hard part of starch. Previous studies reported that yeast (*Saccharomyces cerevisiae*) contained α-amilase, glukoamilase, selulase, sakrosidase dan lipase [8-11], fungus (*Aspergillus niger*) contained α-amilase, α-glukosidase, β-glukosidase, glukoamilase, selulase, protease, lipase, mananase and pectinase [10-12]. Although, previous study argued that kepok banana corm could be used as a source of calories for livestock as it contained 79% carbohydrates, 3385 KCal/kg gross energy, 35% starch but low in protein (3%) [14]. However, there is limited information regarding the utilization of yeast and fungus in kepok banana corm fermentation in ENT province, Indonesia. Therefore, the present study aimed to evaluate the kepok banana corm fermented with yeast and fungus on growing pig nutrient digestibility and mineral Ca and P retention. The hypothesis was that the FKBC fed to growing pig will increase both the nutrient digestibility and mineral Ca and P retention.

2. Materials and Methods

2.1. Animals, Experimental Design and Feeding Management

The study was conducted in Noelbaki Village, Kupang-ENT Province, the village located at distance of ± 25 km to the capital of the ENT Province - Kupang, with altitude of ± 100 m. Sixteen crossbred growing pigs *Duroc x Landrace*, (10 weeks of age; initial body weight 27 ± 3.92 kg), which were obtained from the local farm nearby Kupang city were used. The animals were randomly allotted into one of the four treatments in a randomized block design (n = 4 in each treatment groups). The treatments were consisted of R0: basal feed without FKBC; R1: feed + 7% FKBC; R2: feed + 14% FKBC and R3: feed + 21% FKBC. Feed and water were offered *ad libitum* throughout the course of experiment. The animals were offered feed at three times (08.00, 12.00 and 17.00 oclock) daily to ensure *ad libitum* intakes. Water was provided separately in the bucket.

2.2. Banana Corm Processing and Fermentation

Fresh kepok banana corms, were obtained from local farmers in the district of Kupang, ENT-Indonesia. The microbial yeast (*Saccharomyces cerevisiae*) used had 1.25 x 10^{13} CFU/g and *Aspergillus Niger* had 1.03 x 10^{12} CFU/g, as determined by the Laboratory of Microbiology, Faculty of Veterinary Medicine, Nusa Cendana University (2015).

Kepok banana corms fermentation: Fresh banana corms were sliced from the peal, cut and sun dried for 3 days and ground into flour through a 2 mm screen. Steamed kepok banana corm flour (substrate) was inoculated with the liquid culture at 10% w/v, as recommended by [14]. The inoculated substrates were enclosed within sealed polybags (2 kg capacity) and fermented under aerobic conditions. The fermentation product was inactivated by drying at 60^{o}C for 24 h, as described by [15,16] with modifications, and then stored in sterile plastic bags at 4°C until analysis.

The composition of the feeds used in the present experiment were locally available in this area and commonly used by pig farmers such as corn flour, concentrate, rice bran, fish meal, salt and pigmix. Regarding the present study, corn and rice bran were used as a source of energy and fish meal as a source of protein. The nutrient content of feed used is presented in Table 1.

Table 1. *Contents of experimental diets.*

Feeds sources	Nutrient content	
	Crude Protein (%)	Gross energy (Kcal/kg)
Corn*	8.50	4426
Concentrate**	37.00	3769
Fish meal*	62.90	3770
Rice bran***	13.10	4650
FKBC****	4.40	3511

*) Analysis of Feed Chemicals Laboratory, Faculty of Animal Science, Nusa Cendana University, 2014. **) Commercial Feed Concentrate for Pig. ***) Robles and Ewan, 1982. ****) FKBC = The fermented kepok banana corm, Analysis of Livestock Breeding Center, Bogor, 2015.

The banana corm used in the present study was a fermentation product using a combination of yeast and mold. The treated feeds tested on pigs were formulated with the composition and nutrient content as in Table 2.

Table 2. *Composition of the experimental diets.*

Feed sources	Diet			
	R0	R1	R2	R3
Corn meal (%)	48.00	47.00	46.50	45.50
Concentrate (%)	17.50	18.00	18.00	18.50
Fish meal (%)	12.00	12.50	13.00	13.50
Rice bran (%)	21.00	14.00	7.00	-
FKBC (%)	-	7.0	14.0	21.00
Pigmix (%)	1.00	1.00	1.00	1.00
Salt (%)	0.50	0.50	0.50	0.50
Total	100	100	100	100
*Nutrient composition				

Feed sources	Diet			
	R0	R1	R2	R3
Gross energy (Kkal/kg)	4068	3985	3950	3925
Crude protein (%)	20.85	20.65	20.33	20.13

*Determined values from Table 1.

2.3. Data Collection and Measurement

The measurement of feed consumption included intake of dry matter (DM), Crude protein (CP) and energy were calculated by substracting the daily refusal weight from the weight of the feed offered in the previous day. The digestibility of DM, CP and energy were calculated as the difference between the amount of feed eaten and the amount voided in the faeces. Body weight gain of the pigs were obtained by weighed the animal every week or at the commencement of the study and the end of the study and feed conversion was calculated by deviding the daily intake of nutrients from the body weight gain of the pigs. Retention Mineral Ca and P were calculated by substracting the daily refusal weight of mineral from the weight of the mineral feed offered in the previous day.

2.4. Statistical Analysis

Data were analysed by analysis of variance (ANOVA) with treatment as the sole source of variation in the model. The ANOVA was performed using the IBM SPSS statistics for windows, version 22. Duncan multiple range test was also performed where the level of significant was set at $P < 0.05$.

3. Results and Discussion

3.1. Chemical Composition of the Experimental Diets

The kepok banana corm was chosen in the present study as an alternative feed supplementation to pigs due to its potential production during harvesting seasons but low utilisation particularly in ENT Province, Indonesia where the quantity and quality of feed is mainly constrained on pig production. The diets contained FKBC in the feed composition contain crude protein as high as 21.00%, which indicates high quality feed for growing pigs. The crude protein and energy concentrations are suited and slightly above the needs of grower pigs (Table 3) based on the recommendations of [17]. Mineral P in feed from vegetable was generally low and almost insufficient to meet the needs of animals (18). Minerals content of the diets used in the study are still as recommended needs for growing pigs.

Table 3. *Nutrient content of experimental diets.*

Composition	Diet			
	R0	R1	R2	R3
Dry matter (%)	92.07	90.92	89.61	90.54
Oganic matter (%)	89.02	88.90	87.48	84.88
Crude protein (%)	22.79	22.27	22.73	21.00
Crude fat (%)	6.50	5.32	5.98	5.45
Crude fibre (%)	5.39	5.52	5.82	6.04
CHO (%)	59.73	62.70	60.90	64.09
NFE (%)	54.34	57.18	55.08	58.05
Gross energy (Kcal/kg)	4.303	4.299	4.305	4.294
Ca (%)	0.95	0.81	0.79	0.70
P (%)	0.53	0.51	0.50	0.50

Analysis of feed Chemical Laboratory, Faculty of Animal Science, Nusa Cendana University (2015). CHO = Carbohydrate; NFE = Nitrogen Free Extract

The FKBC used in the diet test contained DM and OM of 89.35±1.06 and 86.36±1.12%, respectively. The crude protein content and crude fat were 4.40 and 1.32%. The content of crude fibre, NDF and energy were 17.51±0.99 and 41.23±1.12% and 3511±48.29 Kcal /kg respectively. The content of starch, resistant starch and total sugar ware 35.54±8.43, 25.91±6.85 and 4.11±2.54 g/100g, respectively (Laboratory of the Department of Food Science and Technology, FTP-IPB-Bogor, Indonesia, 2015). Proximate analysis results of the diets was shown in Table 3.

3.2. Intake and Digestibility of Dry Matter

Dry matter intake of pigs fed the control diets were significantly higher than those fed the test diets ($P< 0.05$; Table 4). The DM intake in this study is consistent with results of previous studies [19] using growing pigs with body weight of 25-50 kg, given a diet containing the amino acid lysine as a supplement, proved that intake of dry matter was 1840 g/day and the mean body weight gain of 802 g/day. The pig intake and growth can be affected by types of feed used and also influenced by different individual pigs. Mwesigwa et al. [20] stated that feed sources helped influence feed intake. Total feed intake can also be influenced by the concentration of energy, palatability, nutritional content, breed and growth rate [21-23].

The DM intake value in the study tends to decrease was because of high starch content in the diet which is still difficult to be digested by the digestive tract of growing pigs. The starch in the FKBC diets is still wrapped by polysaccharides.

The DM digestibility tended to decrease at inclusion level

of FKBC of 21%. Diet containing 7% FKBC (R1) was not significantly (P> 0.05) reduced digestibility of DM compared with the control diet (R0). Feeding growing pigs with 7% FKBC in the diet (R1), however had higher values of DM digestibility than the other treatments.

DM digestibility were not significantly different (P> 0.05) among treatments R0 compared to R1 and between treatment R2 to R3 (Table 4). This finding indicates increasing the level using of the FKBC from 14 up to 21% has not been significantly reduced digestibility of DM. This results noted that utilization of available energy and other nutrients may increase the production of feces and excretion of nutrients.

In this study, DM digestibility tended to decrease indicated that high content of crude fiber and starch in FKBC resulted in duration of component digesta in the digestive tract be short [23]. Since polysaccharide consisting of high starches and resistant starch in the feeds, it will difficult to digest [7,24]. The ability of the digestive tract to digest and absorb carbohydrates (polysaccharide) is influenced by the degree of polymerization, starches physical shape, size and structure of the constituent starch granules [25].

Digestibility of feed containing high starch was also affected by balancing level of amylose: amylopectin of the starch, the higher the amylose content resulted in the lower the digestibility [26], the consequence is the value of the glycemic index increase and occur insulin response [27].

Table 4. *Intake and digestibility of DM in growing pigs (g/day).*

Variables	Treatment diets				Anova P values
	R0	R1	R2	R3	
DM intake	1870,99 ± 37,62^{c}	1654,70 ± 28,92^{b}	610,07 ± 47,93^{a}	1610,07± 42,95^{a}	0.718
DM digestibility	65,05 ±5,45^{bc}	66,57 ±6,34^{c}	60,90 ±1,50^{ab}	57,21 ±2,64^{a}	0.010

^{a,b,c,} values within a row with different superscripts differ, P < 0.05; n = 4 pigs/group

3.3. Intake and Digestibility of Crude Protein and Energy

Intake of CP and energy tended to decrease with increase level of FKBC inclusion. Duncan test on intake of CP and energy indicated that pigs fed the control diets had significantly higher compared to the rest of treatment diets (P<0.05; Table 5).

Table 5. *Intake and digestibility of crude protein and energy.*

Variables	Treatment diets				Anova P values
	R0	R1	R2	R3	
CP intake	426,30±10.89^{b}	393.48±12.53^{a}	376.11±6.44^{a}	338.11±42,95^{a}	0.979
Energy intake	8049.49±161.89^{c}	7596.96±124.36,11^{b}	7596.92±124.36^{b}	7125.05±256.39^{a}	0.908
CP digestibility	83.74 ±^{bc}	66,57 ±6,34^{c}	60,90 ±1,50^{ab}	57,21 ±2,64^{a}	0.810
Energy digestibility	68,95 ±4,72^{bc}	70,48 ±6,34^{c}	65,21 ±1,35^{ab}	62,04 ±2,64^{a}	0.724

^{a,b,c,} values within a row with different superscripts differ, P < 0.05; n = 4 pigs/group

CP digestibility decreases was also due to feed composition, nutrient levels and the possibility of containing protein inhibitors, tannin and saponin. Levels of tannin and saponin in FKBC used in the feed composition were 915.98 and 360 mg/100g. Tannins in feeds, especially high condensed tannin in nonruminant feeds can lead to be less digest and absorb, less palatabel due to bitter taste and the protein bond [28, 29] and also due to bind starch and resistant starch bond [30].

The study showed that using FKBC up to the level of 21% significantly decreased both intake and digestibility of energy. High starch content in FKBC of 350.50 g/kg, resulted in decreasing the energy digestibility of grower pigs. In a study by Jun et al. [27] stated that starch as a source of energy has low digestibility especially when a proportion of amylose: amylopectin is wide. Decomposition of the starch in the digestive tract becomes difficult to digest if containing high amylopectin [31].

3.4. Effect of Treatment on Pig Performances

The present study noted that feed intake of pigs fed R3 diet tended to decrease (Table 6). In other word, the higher the level of FKBC, the lower the feed intake. It was notable that the animal offered R3 diets had the lowest average daily gain (ADG) compared to those fed the control diets. Pigs given feed containing 21% FKBC (R3) tend to consume less feed and less average daily gain.

Table 6. *Effect on feed consumption, body weight gain and feed conversion.*

Performance variables	Treatment diets			
	RO	R1	R2	R3
Feed intake (g/day)	2031,69±40,86^{b}	1987,50±32,53^{b}	1898,87±54,79^{a}	1891,51±70,33^{a}
Avr. DG (g/day)	650,44±76,38	579,46±56,47	594,64±83,73	604,91 ±62,25
Feed Convertion	3,15±0,35	3,45±0,34	3,23±0,51	3,16±0,41

^{a,b,} values within a row with different superscripts differ, P < 0.05; n = 4 pigs/group

The intake of growing pig was influenced by individual animal, age and environment [32], and affected by the concentration of energy [22], palatability, nutrient content, breeds and the rate of growth [23]. Feed with high fibers can cause feed conversion increased as a result of duration of digesta in the digestive tract become shorter [23]. Feed intake in the study is consistent with previous studies using growing pigs with body weight of 25-50 kg, added amino acid lysine as a feed supplement, reported that average value of average daily weight gain was 1840 g/day [19].

The average value of feed conversion showed no differences (P> 0.05) between all diets. This means that the level of 21% FKBC can be administered to growing pigs without lowering the feed conversion. The average feed conversion values obtained are relatively similar between the treatment was due to the nutrient content of feed almost the same (Table 3). Differences in feed conversion rate according to Rideout et al. [33] was closely connected with the process of fermentation in the intestines especially on high starch and resistant starch feeds. Individual animals can also affect the feed conversion [32]. Feed with high crude fibre can cause feed conversion increased [23].

3.5. Mineral Intake and Retention of Ca and P in the Growing Pigs

Mineral intake of Ca and P found tends to decrease with increasing the levels of FKBC inclusion, as shown in Table 7.

Table 7. *Mineral intake and retention of Ca and P (g/day).*

Variables	Treatment diets				Anova P values
	R0	R1	R2	R3	
Ca intake	17,82±0,35^{d}	14,32±0,23^{c}	13,20±0,38^{b}	11,28±0,41^{a}	0.989
P intake	9,91±0,19^{d}	9,08±0,14^{b}	8,35±0,24^{a}	8,06±0,29^{a}	0.949
Ca retention	15,08±1,18^{d}	11,87±0,86^{c}	10,77±0,78^{b}	8,59±0,75^{a}	0.978
P retention	8,20±0,57^{c}	7,49±0,49^{b}	6,66±0,30^{a}	6,30±0,17^{a}	0.932

^{a,b,c,d} values within a row with different superscripts differ, P < 0.05; n = 4 pigs/group

Mineral intake of Ca and P decreased significantly (P <0.05) between the control diet and all the rest. The highest value was achieved in the control diet (RO) and followed by R1, R2 and R3 diets respectively. Duncan's test show the average value of mineral Ca and P intake were no significant difference (P> 0.05) between R2 and R3 diet. Increasing the level of FKBC from 14 to 21% does not significantly reduced mineral Ca and P intake. This presumably due to the mineral content in the FKBC was low.

Mineral Ca retention in pigs fed R0 (control) showed highly significant (P <0.01) compared with R2 diet, whereas the Ca retention between diet R1, R2 and R3 were significant difference (P <0.05). The achievement of study was in line with [34] Rideout et al., (2008) stated that source of starch may influence digestibility of mineral Ca and P in growing pigs at 30 kg body weight. Mineral Ca absorption was affected by the balance of Ca and P in the diet [21, 34].

Mineral P retention was found highly significant (P <0.01) between controldiet (R0) compare with R2 and R3 diets. Minerals retention of Ca and P at FKBC inclusion up to 21% was decreased due to high levels of starch and resistant starch content in the FKBC. Previous studies using corn and potato in diet at level of 10% fed in growing pig with body weight of 30 kg was found significantly reduced the digestibility of crude protein and reduces the retention of mineral Ca and P [33]. This sudy indicated that using diets containing hight content of resistant starch has a negative effect on mineral retention of Ca and P in growing pigs.

4. Conclusions and Recommendations

4.1. Conclusion

The inclusion of fermented kepok banana corm at the level of 7% in the diet increased the digestibility *in vivo* dry matter from 65.05 to 66.57 (2.3%). Inclusion of fermented product up to 21% was not reduce the performance of growing pigs.

4.2. Recommendation

It can be recommended banana corm fermented product can be applied as feeds at the level of 21% in growing pigs diet without retarded the intake and growth.

References

[1] Anonymous, 2017. Pig demand and strategy implications. Pig market in Nusa Tenggara Timur (NTT). ARISA, Applied research & innovation systems in agriculture. PRISMA, Promoting rural income through support for markets in agriculture, pp. 12-14.

[2] Anonymous, 2014. East nusa tenggara in the figure. The Central Bureau of Statistics East Nusa Tenggara Province. BPS catalog: 1102001.53

[3] ACIAR. 2010. Final report swine livestock farming commercial use by small farmers in NTT - Opportunity for better market integration. ACIAR GPO Box 1571 Canberra ACT 2601. Australia.

[4] Anonymous, 2010. Final Report Swine Livestock Farming Commercial Use by Small Farmers in ENT - Opportunity for better market integration. ACIAR GPO Box 1571 Canberra ACT 2601. Australia, pp, 50-57.

[5] Diwyanto, K., and Priyanti, A. 2009. The livestock industry development based on local resources. Development of Agricultural Innovation. 2 (3): 208-228

[6] Emaga, T. H., Bindelle, J., Agneesens, R., Buldgen, A., Wathelet, B., and Paquot, M., 2011. Influences ripening banana and plantain peels composition and energy content. Tropical Animal Health Production. (43): 171-177.

[7] Englyst, K. N., S. Liu and H. N. Englyst., 2007. Nutritional characterization and measurement of dietary charbohydrates. Review. European Journal of Clinical Nutrition. (Suppl. I) 519-539.

[8] Aiyer, P. V., 2005. Amylases and their applications. Review. African Journal of Biotechnology, Vol. 4 (13): 1525-1529.

[9] Winarno, F. G., 2010. Food enzym. Revised Ed. M-Brio Press, Bogor.

[10] Uthumporn, U., Zaidul, I. S. M. dan, Karim, A. A., 2010. Hydrolysis of granular starch at sub-gelatinization temperature using a mixture of amylolytic enzymes. Food and bioproducts processing, Vol. 8 8:47–54.

[11] Kaur, R. and Sekhon, B. S. 2012. Enzymes as drugs: an overview. J. Pharm. Educ. Res. Vol 3 (2): 29-41

[12] Anonymous, 2016. Aspergillus niger. Wikipedia The Free Encyclopedia.

[13] https://id.wikipedia.org./wiki/ Aspergillus_ niger. Downloaded date. December 6th, 2016.

[14] Sembiring, S., Pratiwi, T., Osfar, S., and Irfan H. Dj., 2017. Inclusion of kepok banana corm fermentation with *Saccharomyces cerevisiae* and *Aspergillus niger* as feed and Its implications on nutrient digestibility and performance of growing pigs. Disertation at Faculty of Animal Husbandry, Brawijaya University, Malang-Indonesia.

[15] Azizah, N., Al-Baari, A. N., and Mulyani, S., 2012. Duration effect of fermentation of whey substitution with pineapple waste on the production of alkohol, pH and gas. J. Aplikasi Teknologi Pangan, Vol. 1 No. 2:72-77.

[16] Ozturk, S. Koksel, H dan Perry, K.W.Ng. 2009. Characterization of resistant starch samples prepared from two high-amylose maize starches through debranching and heat treatments. Cereal Chemistry, 86(5): 503-510

[17] Jensen, K. H., Damgaard, B. M., Andresen, L. O., Jorgensen, E. dan Carstensen, L., 2013. Prevention of post weaning diarrhoea by a *Saccharomyces cerevisiae* – Derived product based on whole yeast. Animal Feed Sci. and Technol, 183:29-39.

[18] National Research Council., 1998. Nutrient requirements of domestic animals. 10th Revised Edition. Nutrient requirements of swine. National Academy Press, Washington, D.C.

[19] Anselme, P., 2006. Phosphorus optimizing utilization in pig and poultry diets. Secretary General Inorganic Feed Phosphates. A practical guide on the use of inorganic feed phosphates and microbial phytase, Cefic.

[20] Cloutier, L., Pomar, C., Montminy, M. P. L., Bernier, J. F., and Pomar, J., 2015. Evaluation of a real-time method estimating individual in two lines lysine requirements of growing-finishing pigs. Animal, Vol. 9 No. 4, pp 561-568.

[21] Mwesigwa, R., Mutetikka, D. and Kugonza, D. R., 2013. Performance of growing pigs fed diets based on by-products of maize and wheat processing. Tropical Animal Health Production, Vol. 45:441–446.

[22] Tillman, A. D., H. Hartadi, Soedomo, R., Soeharto, P. and Soekanto, L. 1989. Basic feed sciece. Gajah Mada University Press, Animal Sciece Faculty.

[23] Kyriazakis, I., 1994. The Voluntary food intake and diet selection of pigs. In: Principles of pig science. Ed.: D. J. A. Cole. J. Wiseman and M. A. Varley. Nottingham University Press. Pp. 85-105.

[24] Ngoc, T. T. B., Len, N. T and Lindberg, J. E., 2013. Impact of fibre intake and fibre source on digestibility, gut development, retention time and growth performance of indigenous and exotic pigs. Animal, Vol. 7 No. 5, pp 736–745.

[25] Cummings, J. H. and Stephen, A. M. 2007. Carbohydrate terminology and classification. European Journal of Clinical Nutrition, 61 (suppl 1), S5-S18.

[26] Bijttebier, A., Goesaert, H., and Delcour, J. A., 2008. Amylase action pattern on starch polymers. Biologia 63/6: 989-999.

[27] Yin, F., Zhang, Z., Huang, J., dan Yin, Y. 2010. Digestion rate of dietary starch affects systemic circulation of amino acids in weaned pigs. British J. of Nutr. 103:1404-1412.

[28] Jun, H., Daiwen, C. and Bing, Y., 2010. Metabolic and transcriptomic responses of weaned pigs induced by different dietary amylose and amylopectin ratio. Journal PLoS One, Vol. 5, No. 11: 1-7.

[29] Huisman, J., 1989. Factors antinutritional (ANFs) in the Nutrition of monogastric farm animals. In: Nutrition and digestive physiology in monogastric farm animals. Ed.: van Weeden, E. J. and Huisman, J. Pudoc Wageningen, Netherlands. Pp. 17-35.

[30] Lipsa, F. D., Snowdon, R. and Friedt, W., 2012. Quantitative genetic analysis of condensed tannins in oilseed rape meal. Euphytica, Vol.184: 195-205.

[31] Zeeman, S. C., Kossmann, J., dan Smith, A. M., 2010. Starch: Its metabolism, evaluation, and biotechnological modification in plants. Annu. Rev. Plant. Biol. 61:209-234.

[32] Carre, B., 2004. Causes for variation in starch digestibility of feedstuffs among the World's Poultry Science Journal, Vol. 60, pp.: 76-91.

[33] Reeds, P. J., D. G. Burrin, T. A. Davis, M. A. Fiorotto, H. J. Mersmann and W. G. Pond., 1993. Growth regulation with particular reference to the pig. In: Growth of the Pig. Ed: G. R. Hollis. CAB International. pp. 1-32.

[34] Rideout, T. C., Liu, Q., Wood, P., and Fan, M. Z., 2008. Nutrient utilisation and intestinal fermentation are differentially affected by the consumption of resistant starch varities and conventional fibres in pigs. British Journal of Nutrition, 99: 984–992

[35] Whittemore, C. T, 1993. The Sciece and practice of pig production. Longman Scientific & Technical, England.