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# Effect of the Ensiled Taro with Rice Wine by Product or Fish Meal Fed Basal Diet of Rice Bran on Growth Performance of Growing Pigs

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**Abstract:** The experiment was conducted at the research station of Svay Rieng University (SRU) from 01st January 2021 to 30th April 2021, sited in NR 1, Sangkat Chek, Svay Rieng City, Svay Rieng Province, Cambodia. The aim of the study was to determine the effects of inclusion of the ensiled taro foliage with or without of rice wine by product fed a basal diet of rice bran on growth performance and feed conversion ratio of growing pigs. Eight crossbred pigs with average of body weight of 20kg were housed in individual pens and assigned into Randomized Complete Block Design (RCBD) within 4 treatments and 4 replications. The research consisted with four treatments were RW0, RW20, FM10 and RW20FM10. The pigs were weighed every 10 days until 120 days. The pigs were vaccinated against salmonellosis, pasteurellosis and hog cholera. Supplementation of the ensiled taro mixed with rice wine by product or rice wine by product plus fish meal fed basal diet of rice bran was increased the feed intake in dry matter (DM) and organic matter (OM) of the pigs but decreased the feed intakes in crude protein (CP). Final live weight and overall live weight gain in the pigs were higher increased, and feed conversion ratio was improved better as the ensiled taro was used to mixed with rice wine by product or rice wine by product plus fish meal fed basal diet of rice bran. The overall conclusion is that supplement of the ensiled taro mixed with rice wine by product or rice wine by product plus fish meal in the pigs was increased the feed intake and growth rate, and also better feed conversion, than the pigs were supplemented only the ensiled taro or fish meal fed basal diet of rice bran.

**Keywords:** Ensiled Taro Foliage, Rice Wine by Product, Fish Meal, Growth Performance, Feed Conversion Ratio

## 1. Introduction

The forages from cassava, mulberry, sweet potato, taro and water spinach, can all be used successfully in diets for pigs to replace part or all of the protein usually supplied as soybean and/or fish meal. On the basis of research so far, it appears that the foliage of taro (Colocasia esculenta), also known as “Old Cocoyam”, offers the most potential as a protein supplement to replace fish meal and soybean meal as the digestibility of the protein and its biological value are high. The foliage is relatively low in fiber which is reported to be of higher digestibility than the fiber in other protein-rich forages such as mulberry and water hyacinth [5].

Taro plant (Colocacia esculenta) is from the same family of areas. It grows widely in Cambodia, in ponds and waste land. There are two forms of oxalate in taro, one soluble and the other insoluble. The oxalate content was higher in young leaves (589±36 mg/100 g fresh basis) than in older leaves (433±15 mg/100 fresh basis) and that soluble oxalate was 74% of the total oxalate in the leaves [3, 22]. In a survey in Cambodia [3] it was found that farmers traditionally "boiled" the leaves before feeding them to pigs as in the fresh state the leaves were not readily consumed. Recently, ensiling of the taro foliage has been developed [25] and has proved to be effective in reducing the oxalate content [18]. Farmers in Cambodia have experience in

using the leaves and stems of this plant usually by cooking them in order to avoid the irritation to the skin when the leaves and stems are fed fresh [3]. This irritation is known to be caused by oxalate salts in both the leaves and stems [14]. Furthermore, ensiled taro leaves have successfully used by mixing with water spinach to replace 100% of soybean meal in pregnancy and lactation diets for Mong Cai gilts without affecting sow reproduction [6]. Recent research has shown that ensiling the leaves and stems of taro is the most effective way to reduce the concentration of oxalates and that this process is readily accepted by farmers in Vietnam [12]. Rodríguez L and Preston T R (2009) reported the taro stems are rich in soluble sugars thus when they are incorporated in the silage there is no need for conventional silage additives such as molasses or sugar. In addition, the finding that the stem contained a high level of sugars led to the idea of ensiling the leaves and stem together, obviating the need for additional sources of sugars [25].

Rice distillers' by-product or rice wine by product is the residue when rice is fermented and the products of fermentation are then distilled to produce alcohol in an artisan production system. Rice is cooked and yeast is added to the cooked rice for fermentation. The alcohol is distilled from the fermentation liquor, after which the residue is used as a wet feed for pigs. Rice distillers' by-product is produced in large amounts in households in the Mekong delta [16]. Rice distillers' by-product or rice wine by product (known as Bay Srar) is another potential source of high-quality protein in rural areas of Lao PDR. Bay Srar is the residue after distilling the alcohol derived by yeast fermentation of rice [18]. The farmers traditionally use it as a mixture with other feeds such as rice bran and broken rice in diets for fattening pigs [23]. The farmers in Vietnam also use rice distillers' by-product or rice wine by product (Bay Srar) as a traditional feed for pigs [17]. The protein content of "Bay Srar" ranged from 17 to 33% (mean of 23%) in dry matter with a well-balanced array of amino acids [15]. These authors reported that this product could replace completely the fish meal in growing and fattening pig diets with no loss of performance. The rice distillers' by-product has a fairly high protein content (>20% crude protein in dry matter) of good quality with respect to the balance of amino acids [16]. In addition, rural smallholder farmers in Vietnam and Laos have successfully used rice wine by product as a protein source for pigs [19, 29, 20]. Recently it has been hypothesized that rice wine by product fed in small quantities (4% of the diet) also acts as a prebiotic safeguarding cattle from potential toxicity caused by hydrocyanic acid in cassava foliage [2], increasing N retention in growing pigs [27] and improving growth and feed conversion in pregnant-lactating gilts and in the growth rate of their piglets to weaning [28].

The ensiled taro was used successfully by mixing with some protein sources and shown that DM intake, digestibility and Nitrogen retention were increased when the ensiled taro foliage was supplemented with protein-enriched rice or by fish meal mixed with a basal diet of rice bran [11, 21]. In addition, live weight gain was also increased by 36.7% with supplementation of protein-enriched rice compared with 16.5% improvement for supplementation with fish meal [7].

The aim of this research was to determine the effects of inclusion of the ensiled taro foliage into the diets containing with or without of rice wine by product fed a basal diet of rice bran on growth performance and feed conversion ratio of growing pigs.

# 2. Materials and Methods

### *2.1. Location and Climate*

The experiment was conducted at the research station of Svay Rieng University (SRU) from 01st January 2021 to 30th April 2021, sited in NR 1, Sangkat Chek, Svay Rieng City, Svay Rieng Province, Cambodia. The environmental temperature during the experiment ranged from 37 to 38 degrees centigrade.

### *2.2. Experimental Design and Treatments*

A total of 16 crossbred pigs with an average live weight of 21 kg, were allocated to 4 treatments with 4 replications in a Randomized Complete Block Design. The pigs were allocated to the blocks in order of live weight and to treatments within blocks at random. The pigs were allocated to the blocks in order of live weight and to treatments within blocks at random. The pigs were vaccinated against salmonellosis, pasteurellosis and hog cholera. The research treatments were indicated as below and the experimental layout is in Table 1.

RW0: Ensiled taro (52%) and rice bran (48%)

RW20: RW (20%) with ensiled taro (50%) and rice bran (30%)

FM10: FM (10%) with ensiled taro (18%) and rice bran (72%)

RW20FM10: RW (20%) with FM (10%) with ensiled taro (16%) and rice bran (54%).

***Table 1.*** *Layout of the experiment.*

| **Block** | **I** | | **II** | | **III** | | **IV** | |
|---|---|---|---|---|---|---|---|---|
| | **RW20** | **RW20FM10** | **FM10** | **RW0** | **FM10** | **RW20** | **RW20FM10** | **RW0** |
| Pen | FM10 | RW0 | RW20FM10 | RW20 | RW | RW20FM10 | RW20 | FM10 |

The ingredients and chemical composition of the diets are shown in Table 2.

***Table 2.*** *Composition (planned) and chemical composition (calculated by analytical data) of the diets.*

| | RW0 | RW20 | FM10 | RW20FM10 |
|---|---|---|---|---|
| Ingredients | | | | |
| Ensiled Taro (ET) | 52.0 | 50.0 | 18.0 | 16.0 |
| Rice wine by product (RWB) | - | 20.0 | - | 20.0 |
| Fish meal (FM) | - | - | 10.0 | 10.0 |
| Rice bran (RB) | 47.5 | 29.5 | 71.5 | 53.5 |
| Premix plus salt (PS) | 0.50 | 0.50 | 0.50 | 0.50 |
| Chemical composition | | | | |
| Dry Matter (DM) | 47.0 | 40.0 | 73.9 | 67.0 |
| Crude Protein (CP) | 16.6 | 16.5 | 16.7 | 16.6 |
| Organic Matter (OM) | 77.9 | 82.4 | 75.0 | 7.93 |
| Crude Fibre (CF) | 18.0 | 16.8 | 9.1 | 7.93 |

### *2.3. Experimental Feeds and Feeding*

Fresh taro plant was collected from ponds or cannels and produced as taro silage at in the station of Svay Rieng University. For rice wine by product was bought from villagers who make the rice wine as small-scale production. In addition, rice bran, fish meal, premix and salt were purchased only one time at the beginning of the experiment in the local market.

### *2.4. Ensiling the Taro Plant*

Taro plant included leaves and stems were chopped into 2-3 cm pieces, dried under the sun for 2 hours to reduce moisture content then put into plastic bags with pressing of the material to remove the air inside. Finally, the bags were well tied and stored in the plastic container. The ensiled taro was opened and used to feed the pigs after 20 days.

### *2.5. Animals and Housing*

A total of sixteen crossbred pigs were housed in individual pens with wood floors and wood walls. The pens were 1 m wide, 1.5 m in length and 1 m in height. In each experimental pen there was one drinking nipple and one feed troughs for keeping the ingredients of the mixed diets such vegetative protein sources and energy sources. The pens were in an open shed covered by a roof made from steeled structure and zinc. The pigs were vaccinated against common infectious diseases, and de-wormed and then adapted to the diets and the pens for 15 days before starting the experiment.

### *2.6. Feeding System*

The levels of feed offer were based on an expected daily DM feed intake of 3% of pig body weight which was given during the period of adaptation. Offer levels during the collection period were based on the actual recorded intakes during the period of adaptation. Water was freely accessed through drinking nipples.

The ensiled taro, rice wine by product and fish meal were weighed and well mixed with rice bran, premix and salt, and then fed to the pigs in three feeds per day (07.00, 12.00 and 16.00). There were no refusals of any of the feeds after feeding based on the actual recorded intakes during the period of adaptation.

### *2.7. Sample Collection*

The animals were weighed in the morning before feeding, at the beginning of the trial and every 10 days thereafter. Feed offers and refusals were collected and weighed every day, and samples kept frozen at -20°C in plastic bags until analysis. At the end of each 10 days period, samples of feed refused and offered were mixed thoroughly by hand and homogenized in a coffee grinder prior to analysis.

### *2.8. Changes in Live Weight*

The pigs were weighed at the beginning and at every 10 days thereafter until the end of the experiment.

### *2.9. Chemical Analysis*

Chemical analysis of the feed ingredients, diets and refusals were undertaken following the methods of AOAC, (1990) procedures [1] for ash, N, and crude fibre. The DM content was determined using the microwave method of Undersander et al. (1993) [30]. All analyses of the samples were conducted in duplicate. NDF and ADF was analyzed according to Van Soest P J, et al. (1991) [31].

### *2.10. Statistical Analysis*

The data for feed intake, feed conversion and growth rate were compared by using the software program of Minitab version (16) [21] with $P<0.05$. The sources of variation were: Treatments, pigs and error.

## 3. Results and Discussion

### *3.1. Chemical Characteristics*

***Table 3.*** *Chemical composition of the feed ingredients (% as DM).*

| Ingredients | DM % | As % of DM | | |
|---|---|---|---|---|
| | | CP | OM | CF |
| Ensiled Taro (ET) | 8.92 | 22.3 | 81.2 | 30.2 |
| Rice wine by product (RWB) | 45.5 | 11.2 | 98.2 | 1.53 |
| Fish meal (FM) | 88.6 | 51.3 | 67.3 | 1.77 |
| Rice bran (RB) | 88.1 | 10.5 | 75.1 | 4.88 |
| Premix plus salt (PS) | 98.0 | nd | nd | nd |

nd=not determined.

The chemical characteristics of dietary ingredients are shown in Table 3. The dry matter (8.92%) and crude protein (22.3%) in the DM of the ensiled taro were slightly lower than to the finding reported by Hang D T and Preston T R (2009) [13]. However, crude fiber (30.2%) in the DM of the ensiled taro was higher than to the resulted by these authors due to the ensiled taro was made by mixing both of stem and leaves. DM (45.5%) of rice wine by product was higher than to the results reported by Phiny C, et al. (2012) [7]. However, CP (11.2%) of rice wine by product was lower than to that reported by these authors. The contrast results were probably caused by the different adding the yeast levels from rice wine producers. The crude protein (51.3%) and organic matter (67.3%) in the DM of the fish meal were higher than to the report found by

Buntha P, et al. (2007) [24] but dry matter (88.6%) of fish meal in current study was similar to those authors. DM (88.1%), CP (10.5%) and CF (4.88%) of rice bran in the present research were similar to the results found by Hang D T and Preston T R (2009) [13] but OM (75.1%) of rice bran was slightly lower than found by these authors.

The pigs grew faster in good health and gained in live weight during and after the experiment. There were no symptoms or signals of discomfort from the consumption of the diets.

### *3.2. Feed Intake*

The total of feed intakes in dry matter (DM) and organic matter (OM) in pigs fed the ensiled taro with rice wine by product or fish meal mixed with a basal diet of rice bran were higher in the treatments that contained rice wine by product of 20% (RW20) and rice wine by product 20% plus fish meal of 10% (RW20FM10) as compared with treatment contained without rice wine by product (RW0) and ensiled taro plus fish meal 10% (FM10) (P<0.001) while the intakes of crude protein (CP) was higher in treatment of FM10 compared with another three treatments (P<0.001). The current findings were this was similar to the finding of Lotchana T and Preston T R (2010) [18] when the author used the rice distiller's by-product with other ingredient such as rice bran and water spinach for Moo Laat or Mong Cai pigs, and also this was similar to the results found by Bounlerth S, et al. (2018) [4] as fed the rice distiller's by-product mixed with the ensiled banana pseudo stem, ensiled taro foliage and broken rice in term of DM and CF intakes of the pigs in treatment without rice wine by product (RW0) (P<0.001) (Table 4 and Figure 1 and Figure 2).

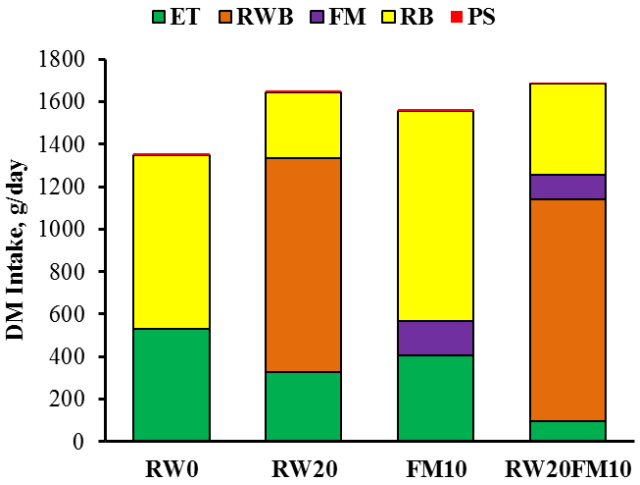


***Figure 1.*** *Feed intake in pigs fed the ensiled taro with rice wine by product or fish meal mixed with a basal diet of rice bran.*

***Table 4.*** *Mean values of feed intake in pigs fed the ensiled taro with rice wine by product or fish meal mixed with a basal diet of rice bran.*

| | RW0 | RW20 | FM10 | RW20FM10 | SEM | P-value |
|---|---|---|---|---|---|---|
| DM intake, g/day | | | | | | |
| ET | 530 | 328 | 403 | 94.9 | 5.32 | |
| RWB | - | 1,005 | - | 1,047 | 9.57 | |
| FM | - | - | 166 | 114 | 1.52 | |
| RB | 817 | 312 | 989 | 428 | 7.93 | |
| PS | 3.66 | 4.22 | 5.54 | 7.18 | 0.09 | |
| Total | 1,351$^{c}$ | 1,649$^{a}$ | 1,562$^{b}$ | 1,691$^{a}$ | 18.9 | <0.001 |
| DM, g/kg LW | 43.8$^{b}$ | 45.2$^{a}$ | 43.7$^{b}$ | 38.0$^{c}$ | 0.31 | <0.001 |
| Total CP, g/day | 199$^{c}$ | 210$^{c}$ | 275$^{a}$ | 234$^{b}$ | 3.00 | <0.001 |
| Total OM, g/day | 1,059$^{c}$ | 1,498$^{a}$ | 1,143$^{b}$ | 1,477$^{a}$ | 15.9 | <0.001 |
| Total CF, g/day | 207$^{a}$ | 150$^{c}$ | 174$^{b}$ | 83.2$^{d}$ | 2.28 | <0.001 |

abcd Mean values within row without a common letter are different at P<0.05.

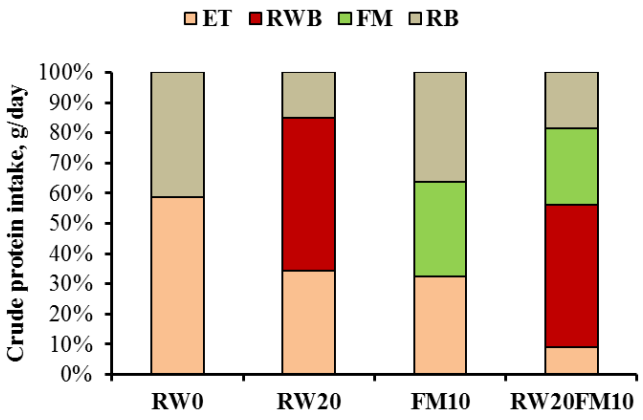


***Figure 2.*** *Mean values for percentage of dietary crude protein intake in pigs fed the ensiled taro with rice wine by product or fish meal mixed with a basal diet of rice bran.*

### *3.3. Growth and Feed Conversion*

There was very significant difference (P<0.001) for growth rate in both of final live weight and overall live weight gain of the pigs for the treatment contained with rice wine by product (RW20 or RW20FM10) as compared to the treatment without contained rice wine by product (Table 5, Figure 3 and Figure 4). The results to be similar to those reported for supplementation of pig diets with rice distillers' by-product (Luu Huu Manh et al 2003 [15], 2009 [16]; Lotchana T and Preston T R (2010) [18]). Moreover, the current findings were probably in rice wine by product was a good source of lysine to balance of amino acid profile in the diets contained rice wine by product for growing pigs and these results were similar to the studied by Harmon BG (1974) [9], (1975) [10] and Cromwell et al (1993) [8], and also similar to the report found by Bounlerth S, et al. (2018) [4] who used the rice

distillers' by-product mixed with basal diet of ensiled banana pseudo stem/taro foliage, broken rice plus soybean meal for growth performance of Moo Lath pigs. And according to Shetty et al. (2006) [26] was indicated that distillers' by-products contain the remains of the yeast that produce the alcohol, the cell wall of *S cerevisiea* contains a scaffold of β-glucans attached to highly glycoslylated mannoproteins that can bind numerous compounds, microorganisms or provide habitat for biofilm formation with other diets for growing pigs.

There were very significantly differences (P<0.001) in overall feed conversion were numerically improved for the diets were supplemented with rice wine by product (RW20 or RW20FM10) as compared with the diets without rice wine by product (RW0 or FM10) (Table 5 and Figure 5), and to that finding was agreed with Phiny C, et al. (2012) [7] who fed a basal diet of cassava root meal with supplements of rice wine by product mixed with ensiled taro leaves plus stem for growing pigs. In addition, the results were similar to the previous published by Bounlerth S, et al. (2018) [4] and Lotchana T and Preston T R (2010) [18] as the rice distillers' by-product was added with basal diet of ensiled banana pseudo stem/taro foliage, broken rice plus soybean meal for Moo Lath pigs, and supplemented or not with rice distillers' by-product for Mong Cai and Moo Laat pigs respectively.

***Table 5.*** *Mean values for main effects on growth rate and feed conversion ratio in pigs fed the ensiled taro with rice wine by product or fish meal mixed with basal diet of rice bran.*

| | RW0 | RW20 | FM10 | RW20FM10 | SEM | P-value |
|---|---|---|---|---|---|---|
| Live weight, kg | | | | | | |
| Initial | 21.3 | 20.3 | 21.0 | 20.5 | 1.97 | 0.983 |
| 30 days | 28.7 | 32.2 | 29.7 | 34.1 | 2.67 | 0.505 |
| 60 days | 35.7 | 44.4 | 39.0 | 46.7 | 2.87 | 0.071 |
| 90 days | 42.6$^{c}$ | 58.2$^{ab}$ | 49.2$^{bc}$ | 63.6$^{a}$ | 3.37 | 0.004 |
| Final | 49.7$^{c}$ | 72.5$^{ab}$ | 61.5$^{bc}$ | 78.7$^{a}$ | 3.57 | <0.001 |
| Live weight gain, g/day | | | | | | |
| 0 - 30 days | 203$^{b}$ | 324$^{ab}$ | 236$^{b}$ | 368$^{a}$ | 29.3 | 0.006 |
| 30 - 60 days | 233$^{c}$ | 404$^{ab}$ | 308$^{b}$c | 421$^{a}$ | 23.8 | <0.001 |
| 60 -90 days | 229$^{c}$ | 463$^{ab}$ | 342$^{bc}$ | 563$^{a}$ | 31.8 | <0.001 |
| 90 - 120 days | 238$^{b}$ | 475$^{a}$ | 408$^{ab}$ | 504$^{a}$ | 43.9 | 0.005 |
| 0 - 120 days | 238$^{c}$ | 435$^{a}$ | 338$^{b}$ | 485$^{a}$ | 18.8 | <0.001 |
| FCR, kg/kg of body weight | | | | | | |
| 0 - 30 days | 5.24$^{a}$ | 3.69$^{bc}$ | 4.82$^{ab}$ | 3.38$^{c}$ | 0.33 | 0.005 |
| 30 - 60 days | 5.07 | 3.74 | 4.71 | 3.63 | 0.4 | 0.072 |
| 60 -90 days | 6.54$^{a}$ | 3.82$^{b}$ | 5.11$^{ab}$ | 3.31$^{b}$ | 0.42 | 0.001 |
| 90 - 120 days | 7.39$^{a}$ | 4.49$^{b}$ | 5.16$^{b}$ | 4.40$^{b}$ | 0.51 | 0.004 |
| 0 - 120 days | 5.72$^{a}$ | 3.78$^{bc}$ | 4.64$^{b}$ | 3.45$^{c}$ | 0.22 | <0.001 |

abc Mean values within row without a common letter are different at P<0.05.

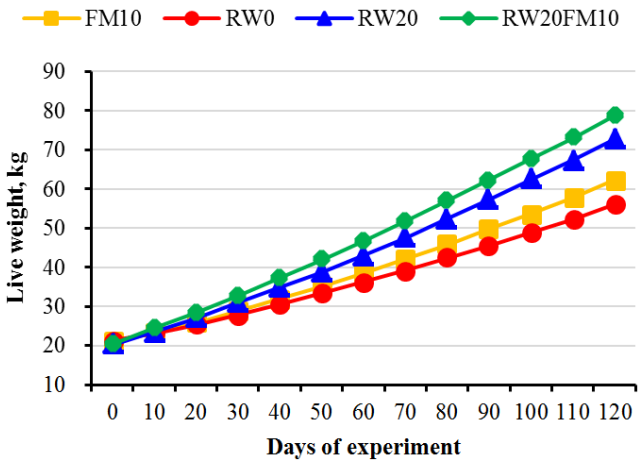


***Figure 3.*** *Growth curves of pigs fed the ensiled taro with rice wine by product or fish meal mixed with a basal diet of rice bran.*

The relationship between DM feed intake and live weight gain was slightly linear related to DM intake (Figure 6). This result was similar to the report led by Phiny C, et al. (2012) [7] as the author fed the rice wine by product mixed with ensiled taro leaves plus stem for pigs. However, it was better improved on DM feed conversion ratio in relation between DM intake and DM feed conversion (Figure 7). And to this, there appear to be no reports on the use of rice wine by product mixed with other diets in term of relationship between DM intake and DM feed conversion of which similar to that described in this research paper.

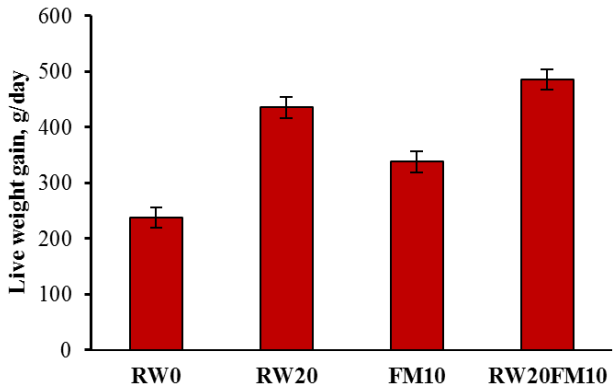


***Figure 4.*** *Live weight gain for pigs fed the ensiled taro with rice wine by product or fish meal mixed with a basal diet of rice bran.*

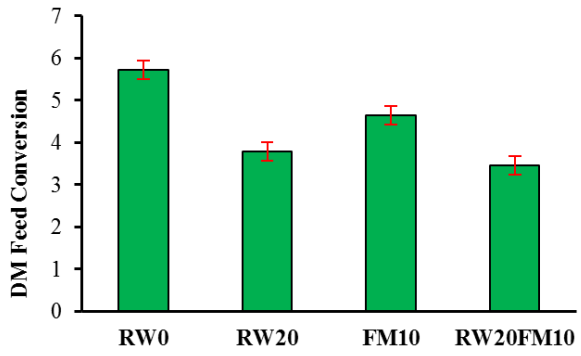


***Figure 5.*** *Feed conversion ratio of dry matter in pigs fed the ensiled taro with rice wine by product or fish meal mixed with a basal diet of rice bran.*

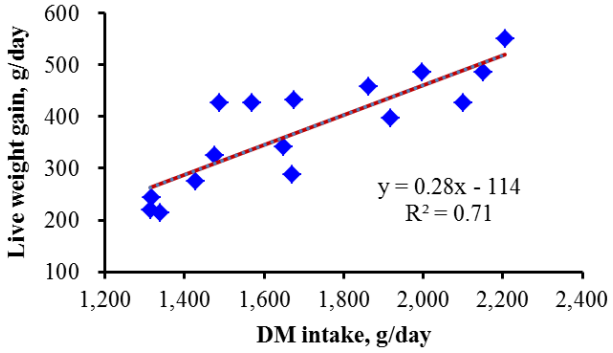


***Figure 6.*** *Relationship between DM intake and live weight gain in pigs fed the ensiled taro with rice wine by product or fish meal mixed with a basal diet of rice bran.*

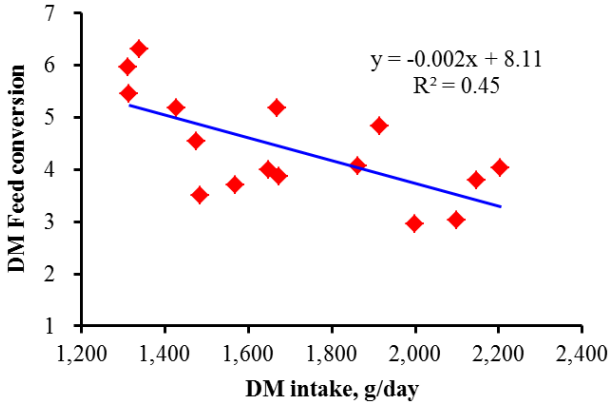


***Figure 7.*** *Relationship between DM intake and feed conversion ratio in pigs fed the ensiled taro with rice wine by product or fish meal mixed with a basal diet of rice bran.*

# 4. Conclusions

Supplementation of the ensiled taro mixed with rice wine by product or rice wine by product plus fish meal fed basal diet of rice bran was increased the feed intake in dry matter and organic matter of the pigs but decreased the feed intakes in crude protein.

Final live weight and overall live weight gain in the pigs were higher increased, and feed conversion ratio was improved better as the ensiled taro was used to mixed with rice wine by product or rice wine by product plus fish meal fed basal diet of rice bran.

The overall conclusion is that supplement of the ensiled taro mixed with rice wine by product or rice wine by product plus fish meal in the pigs was increased the feed intake and growth rate, and also better feed conversion, than the pigs were fed only the ensiled taro or fish meal with basal diet of rice bran.

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