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Utilization of Ensiled Taro Mixed With Rice Wine by Product or Fish Meal Fed Basal Diet of Rice Bran on Reproduction and Piglet Performance in Sows in Cambodia

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Abstract: In Cambodia, pig raising plays an important role as it provides meat and also increasing family income. Currently, researchers are trying to find the feeds that focus on using locally available natural resources as animal feeds can be used to reduce the cost of expensive feed on market such as soybean or fish meal. Based on that one experiment was designed and conducted at the campus of Svay Rieng University from 01st April to 15th September 2022, sited in NR 1, Sangkat Chek, Svay Rieng City, Svay Rieng Province. The aim of this experiment was to compare the feed intake of sows, the piglet performance in lactation, and the reproductive traits after weaning. Twelve sows were assigned according to Completely Randomized Design (CRD) within 3 treatments and 4 replications. The treatments of experiment were RW0, RWB20, and FM10. The results of the experiment were found that the total of feed intake in dry matter (DM) during pregnancy and lactation, were higher significantly different for the treatment of RWB20 ($P < 0.01$). There were no effects of all treatments on parameters in total litter size, mortality and total litter size live born of piglet performance at birth, except for total litter weight and mean live weight which was higher significantly different for RWB20 ($P < 0.01$). Non-significant different among the treatments on parameters in total litter size, mortality and mean piglet live weight at 21 days, except for total litter weight and litter weight change for RWB20 ($P<0.01$). There were higher significantly different for treatment of RWB20 in total litter size, total litter weight, litter weight change and mean piglet live weight at 45 days ($P < 0.01$). And there were no effects among the treatments on parameters in weaning to estrus, cycle of reproduction and number of litters per year in reproduction traits. However, length of pregnancy was higher significantly different for RWB20 ($P < 0.01$). It is concluded that a mixture of ensiled taro (10%) and rice wine by product (20%) were higher increased on feed intake of sows in pregnancy and lactation stages, higher increased on total litter size, total litter weight, litter weight change and mean piglet live weight in lactation period, and better effects on reproductive traits in weaning to estrus, cycle reproduction and number of litters per year. Using protein from a mixture of the ensiled taro and rice wine by product could successfully reduce the cost of pig feeds.

Keywords: Ensiled Taro, Rice Wine by Product, Fish Meal, Reproduction

1. Introduction

In view of the increasing costs of concentrate feeds, and especially protein concentrates such as soybean and fish meal, recent research in Vietnam, Cambodia and Laos has been directed to the use of leaves from crops such as cassava [12, 6], sweet potato [2, 7], and mulberry [30], and water plants such as water spinach [25] and duckweed [32].

Taro (*Colocasia esculenta* (L.) Schott) can be a potential protein source for animals, especially pigs due to the good nutritional quality of the leaves. Many studies have been done on using taro for pig [7, 39, 31, 33]. Chittavong et al (2008) [8] reported that a mixture of taro silage and water spinach can replace 100% of soybean meal in pregnancy and lactation diets

for local bread Mong Cai gilts without affecting sow reproduction. Sivilai et al (2010) [34] have concluded that a mixture of taro leaf silage and water spinach can be used in the diet of Mong Cai gilts in pregnancy and lactation without affecting reproduction criteria, measured as numbers of live piglets born and weaned, and the interval from weaning to estrus. The sows can obtain these nutrients by feeding them a high forage diet. Hoang Nghia Duyet et al (2003 and 2004) [17, 18] showed that a suitable proportion of forage leaves in the diet of Mong Cai sows is 30-40% (in DM) in the pregnancy period and 20-30% in the lactation period. 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, 27]. 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 [33] and has proved to be effective in reducing the oxalate content [22]. 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 [15]. 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 [7]. 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 [38]. 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.

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 [20]. 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 [22]. The farmers traditionally use it as a mixture with other feeds such as rice bran and broken rice in diets for fattening pigs [28]. The farmers in Vietnam also use rice distillers' by-product or rice wine by product (Bay Srar) as a traditional feed for pigs [21]. 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 [19]. 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 [23, 37, 24]. 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 pig [35] and improving the growth rate and feed conversion in pregnant-lactating gilts and in the growth rate of their piglets to weaning [36].

Fish meal in feeds for pig and poultry was based on the ability of fishmeal to provide high levels of protein, with a good amino acid profile, in a highly digestible format for the animal. Fish and fishery products represent a valuable source of animal protein, as a portion of 150 g of fish provides about 50–60% of the daily protein requirements [41]. Cho and Kim (2011) [10] comparing with fishmeal with other animal feed ingredients such as rendered meat meal, poultry byproduct meal, blood meal and soybean meal, illustrating that it is the balanced amino acid profile of the fishmeal (and especially being rich in methionine and lysine) that provides fishmeal with nutritional advantages.

Rice bran in Cambodia varies according to rice variety, but much more depending on the milling process. Rice bran contains on average around 12.9% CP and 8.6% CF. Harris and Staples, (2003) [16] also reported that rice bran contains about 12% CP, 12% fat, 10% CF and 60% TDN (as fed). Narasinga Rao, (2000) [26] found that rice bran has a higher lysine content and a lower glutamic acid content than rice and wheat, and it has a better balance of essential amino acids, with an amino acid score of 80 per cent with respect to lysine, and 90 per cent with respect to threonine. Rice bran is a good source of energy and essential fatty acids (EFA), and also a rich source of B-complex vitamins, particularly thiamine and nicotinic acid, and some other minor B-vitamins.

The aim of the study was to determine the effects of a mixture of ensiled taro and rice wine by product on feed intake of sows in pregnancy and lactation stages, piglet performance in lactation, and reproductive traits after weaning.

2. Materials and Methods

2.1. Location and Climate

The experiment was conducted at the research station of Svay Rieng University (SRU) from 01st April to 15th September 2022, sited in NR 1, Sangkat Chek, Svay Rieng City, Svay Rieng Province, Cambodia. The environmental temperature during the experiment ranged from 37 to 39 degrees centigrade.

2.2. Experimental Design and Treatments

A total of 12 crossbred sows with an average live weight of 105 kg, were allocated into 3 treatments with 4 replications in a Completely Randomized Design (CRD). The sows were vaccinated against salmonellosis, pasteurellosis and hog cholera. The research treatments were indicated as below and the experimental layout is in Table 1.

1) RW0: Ensiled taro (15%), Fish meal (14%), Rice bran

(70.5%), and Premix/salt (0.5%).

2) RWB20: Ensiled taro (10%), Rice wine by product (20%), Fish meal (15%), Rice bran (54.5%), and Premix/salt (0.5%).
3) FM10: Ensiled taro (5%), Fish meal (16%), Rice bran (78%), and Premix/salt (0.5%).

Table 1. *Layout of the experiment.*

Sow Pens	FM10	RWB20	FM10	RWB20	RWB0	RWB20
	RWB0	FM10	RWB20	RWB0	FM10	RWB0

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.*

Ingredient	**RW0**	**RWB20**	**FM10**
Ensiled Taro (ET)	15	10	5
Rice wine by product (RWB)	0	20	0
Fish Meal (FM)	14	15	16
Rice bran (RB)	70.5	54.5	78.5
Premix/salt (P/S)	0.5	0.5	0.5
Chemical composition			
Dry Matter (DM)	76.7	64.8	84.4
Crude Protein (CP)	17.1	17.3	17.0
Organic Matter (OM)	74.5	78.8	5.62
Crude Fibre (CF)	8.22	6.25	5.62

2.3. Experimental Feeds and Feeding

Taro leaf plus stem was collected from ponds or cannels and produced as the ensiled taro at 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 at local market closed to the station.

2.4. Ensiling the Taro Plant

Taro plant included leaf and stem 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 in the plastic containers were well tied and stored at safe place. The ensiled taro was opened and used to feed the sows after three weeks.

2.5. Animals and Housing

A total of twelve crossbred sows were housed in individual pens with concrete floors and brick walls. The pens were 2 m wide, 2.5 m length and 1.2 m height. In each experimental pen there was one drinking nipple and one feed trough for keeping the ingredients of the mixed diets, and one room connected with the sow's pen for keeping the piglets when they get birth. The pens were in an open shed covered by a roof made from steeled structure and zinc. The sows were vaccinated against common infectious diseases, and de-wormed and then adapted to the diets and the pens for 20 days before carrying out the experiment.

2.6. Feeding System

The levels of feed offer were based on an expected daily DM feed intake which was given during the period of adaptation. Offer levels during the collection period were based on the actual recorded intakes during 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 sows. The mixed feed allowance was fixed at 2.5% of body weight in pregnancy and adlibitum in lactation. Protein levels were 17% in DM in the diets for pregnancy and lactation (Table 2). The sows were given three times per day (07:00, 11:00 and 17:00. There were no refusals of any of the feeds after feeding based on the actual recorded intakes during the adaptation period.

2.7. Measurements

DM feed intakes were recorded in pregnancy and lactation stages. Number of piglets at the births and mortality rate (%) of the piglets after birth and during lactation stage. Litter size at birth and at weaning (piglets/ litter). Live weight of the piglets at birth and at weaning (kg/piglet). Litter weight of piglets at birth and at weaning stage. And mean piglet live weight.

2.8. Changes in Live Weight of Piglets

The piglets were weighed at birth, 21 days and 45 days of ages at weaning stage during the experimental period.

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 by using the microwave method of Undersander et al. (1993) [40]. All analyses of the samples were conducted in duplicate.

2.10. Statistical Analysis

The data for feed intake of sows, piglet performance and reproductive traits were compared by using the software program of Minitab version (16) with P<0.05. The Tukey pair-wise comparisons with a confidence level of 95 was used to determine the effects of dietary treatments. The sources of variation were: treatments, sows, piglets 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)	11.2	22.1	81.2	30.2
Rice wine by product (RWB)	9.20	10.5	98.2	1.53
Fish meal (FM)	88.0	52.5	67.3	1.77
Rice bran (RB)	88.3	10.3	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 (11.2%) and crude protein (22.1%) in the DM of the ensiled taro were slightly lower than to the finding reported by Hang D T and Preston T R (2009) [14]. However, crude fiber (30.2%) in the DM of the ensiled taro was higher than to the finding resulted by the authors due to the ensiled taro at the current research was made by mixing both of stem and leaves. The dry matter (9.20%) of rice wine by product was similar to the results reported by Phiny et al. (2012) [9]. However, CP (10.5%) of rice wine by product was lower than to that report of these authors. The contrast results were probably caused by the different composition of the yeast product from the producers. The crude protein (52.5%) 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) [29] but dry matter (88.0%) of fish meal in current study was similar to those authors. Dry matter (88.3%), Crude protein (10.3%) and Crude fibre (4.88%) of rice bran in the current research were similar to the results found by Hang D T and Preston T R (2009) [14] but it was slightly lower for Organic matter (75.1%).

The piglets grew faster in good health and gained in live weight during and after the experiment. For sows also were good health in both of pregnancy and lactation stages. There were no symptoms or signals of discomfort from the consumption of the diets.

3.2. Feed Intake

The total of feed intake in dry matter (DM), crude protein (CP) and organic matter (OM) for the two periods of pregnancy and lactation, were higher and very significant different for the treatment of RWB20 as compared to the treatment of RW0 and FM10 (P<0.01). The current findings were this was higher to the finding of Du Thanh Hang et al (2019) [13] when the author used the rice distiller's by-product of 5% levels mixed with other ingredients such as the ensiled taro, maize and fish meal, and also higher to the finding of Bounlerth et al (2018) [4] as fed the rice distiller's by-product mixed with the ensiled banana pseudo stem, ensiled taro foliage, soybean meal and soybean oil. However, this was similar to the results found by Tran Thanh Hai et al (2013) [38] as the author replaced fish meal by a mixture of the ensiled taro and ensiled sweet potato vines during Lactation period. (Table 4 and Figure 1 and Figure 2).

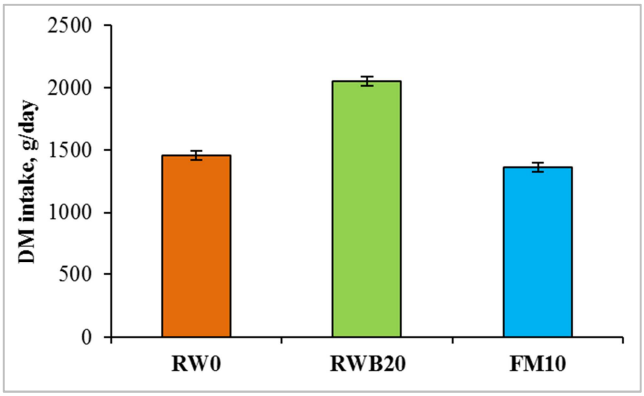

Figure 1. *Feed intake in sows fed the ensiled taro, rice wine by product and fish meal with a basal diet of rice bran, during pregnancy stage.*

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

	RW0	RWB20	FM10	SEM	P-Value
No of sows	4	4	4		
Pregnancy Period					
Dry Matter (DM), g/day	1455^{b}	2051^{a}	1358^{b}	36.3	<0.001
Crude Protein (CP), g/day	258^{a}	265^{a}	238^{b}	5.76	0.004
Organic Matter (OM), g/day	1062^{b}	1827^{a}	980^{b}	30.1	<0.001
Crude Fibre (CF), g/day	109^{a}	66.2^{c}	77.7^{b}	2.29	<0.001
Lactation Period					
Dry Matter (DM), g/day	1940^{b}	2901^{a}	1810^{b}	73.2	<0.001
Crude Protein (CP), g/day	344^{b}	409^{a}	318^{b}	11.5	<0.001
Organic Matter (OM), g/day	1416^{b}	2532^{a}	1306^{b}	59.3	<0.001
Crude Fibre (CF), g/day	146^{a}	94.2^{b}	104^{b}	4.76	<0.001

^{abc} Mean values within rows with different superscript letters are significantly different (P<0.05)

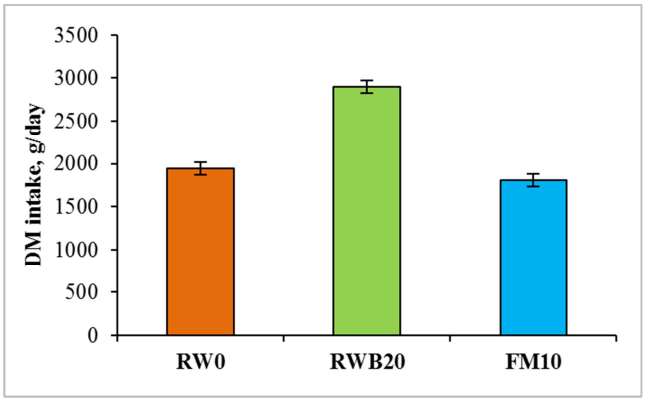

Figure 2. *Feed intake in sows fed the ensiled taro, rice wine by product and fish meal with a basal diet of rice bran, during lactation stage.*

3.3. Piglet Performance in Lactation

There were no effects of all treatments on parameters in total litter size, mortality and total litter size live born of piglet performance at birth, except for total litter weight and mean live weight which was higher significantly different for RWB20. However, there were no significant differences as compared between FM10 and RW0 (Table 5, Figure 3). The findings were similar to those reported by Bounlerth et al (2010) [5] who fed a mixture of rice bran and maize meal supplemented with water spinach and taro leaf silage, and to that finding was agreed with Tran Thanh Hai et al (2013) [38]. However, contrast results on parameters of total litter weight and mean live weight at birth which fed a mixture of ensiled taro foliage and ensiled sweet potato vines.

There were not significant different among the treatments on parameters in total litter size, mortality and mean piglet live weight at 21 days of ages, except for total litter weight and litter weight change which was higher significantly different for RWB20 as compared with FM10 (Table 5, Figure 4). The current results were agreed to those reported by Chittavong et al (2008) [8] and Bounlerth et al (2010) [5], who fed a mixture of taro leaf silage and water spinach, and a mixture of rice bran and maize meal supplemented with water spinach and taro leaf silage respectively. However, contrast findings to those results by Tran Thanh Hai et al (2013) [38] and Chhay Ty et al (2014) [11], who fed a mixture of ensiled taro foliage and ensiled sweet potato vines, and ensiled taro foliage replacing rice bran in diets respectively. The differences were probably caused by the current findings was used rice wine by product mixed with taro silage of which a good source of lysine to balance of amino acid profile in the diets for growing pigs.

There were higher significant different for treatment of RWB20 in total litter size, total litter weight, litter weight change and mean piglet live weight at weaning 45 days of ages, except for mortality (Table 5, Figure 5). The current findings were similar to those studies by Bounlerth et al (2010) [5], and were in agreement with the report of Chittavong et al (2008) [8]. However, contrast findings to those results from Chhay Ty et al (2014) [11] on parameters in total litter weight and mean piglet live weight who fed ensiled taro foliage replacing rice bran in diets during lactation stage.

Table 5. *Mean values of piglet performance in sows fed the ensiled taro, rice wine by product and fish meal with a basal diet of rice bran.*

	RW0	RWB20	FM10	SEM	P-Value
At birth					
Total litter size	10.0	11.0	10.6	1.50	0.89
% Mortality	0.33	0.33	2.00	0.92	0.39
Total litter size live born	9.00	10.6	8.66	0.63	0.13
Total litter weight, kg	8.76^{b}	13.9^{a}	7.66^{b}	0.40	<0.001
Mean live weight, kg	0.97^{b}	1.31^{a}	0.89^{b}	0.03	<0.001
At 21 days					
Total litter size	9.00	10.3	8.33	0.63	0.16
% Mortality	0.33	0.11	0.33	0.27	0.63
Total litter weight, kg	37.5^{b}	45.6^{a}	33.1^{b}	1.11	0.001
Litter weight change, kg	28.7^{ab}	31.7^{a}	25.4^{b}	0.92	0.009
Mean piglet live weight, kg	4.19	4.42	4.01	0.19	0.38
At weaning 45 days					
Total litter size	8.66^{b}	10.7^{a}	8.00^{b}	0.43	0.008
% Mortality	0.33	0.15	0.33	0.27	0.63
Total litter weight, kg	39.6^{b}	55.3^{a}	34.8^{b}	2.92	0.007
Litter weight change, kg	30.9^{ab}	41.4^{a}	27.1^{b}	2.64	0.02
Mean piglet live weight, kg	4.57^{ab}	5.19^{a}	4.31^{b}	0.18	0.04

^{ab} Mean values within rows with different superscript letters are significantly different (P<0.05)

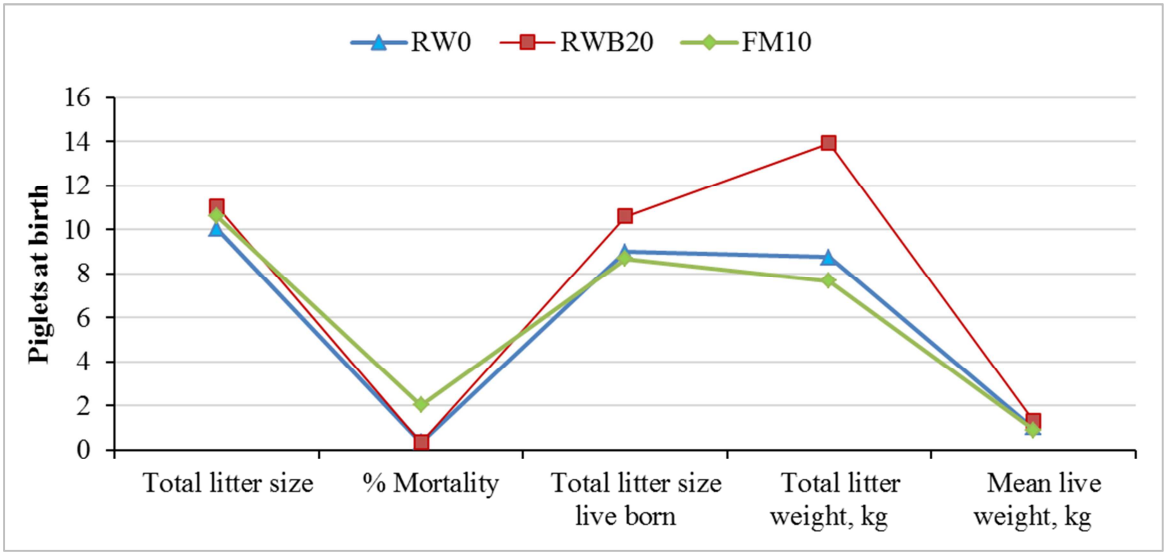

Figure 3. *Piglet performance at birth fed the ensiled taro, rice wine by product and fish meal with a basal diet of rice bran.*

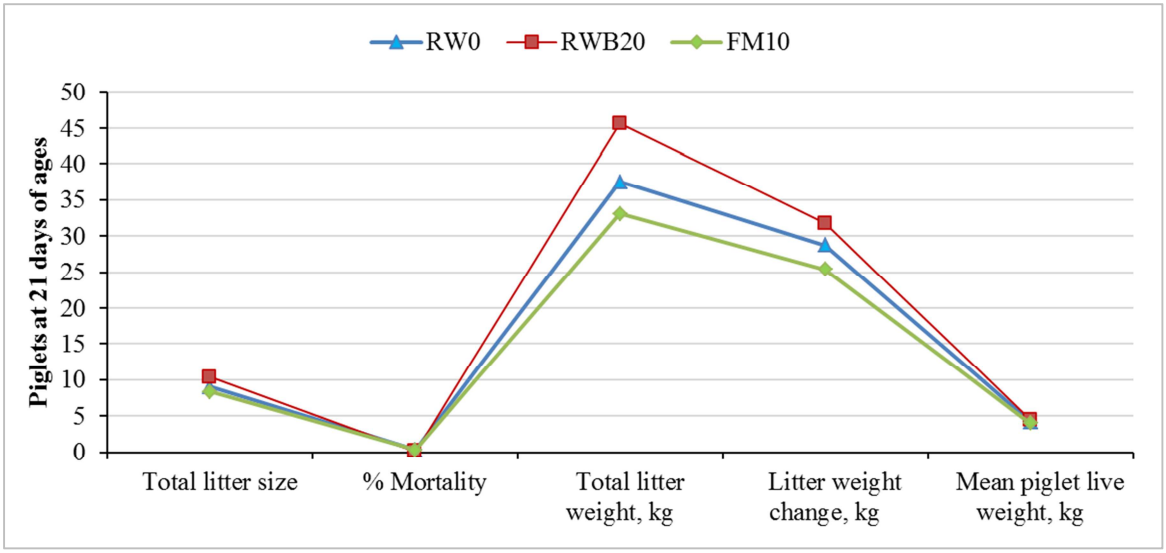

Figure 4. *Piglet performance at 21 days of ages fed the ensiled taro, rice wine by product and fish meal with a basal diet of rice bran.*

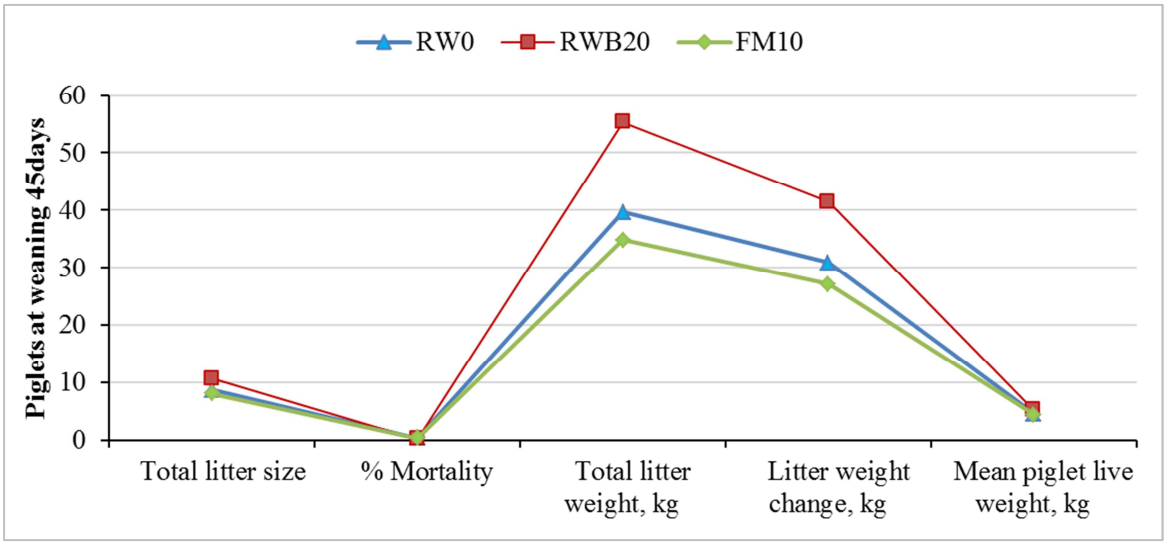

Figure 5. *Piglet performance at 45 days of ages fed the ensiled taro, rice wine by product and fish meal with a basal diet of rice bran.*

3.4. Reproductive Traits

Table 6. *Mean values of reproductive traits in sows fed the ensiled taro, rice wine by product and fish meal with a basal diet of rice bran.*

	RW0	RWB20	FM10	SEM	P-Value
Weaning to estrus, days	15.6	14.3	16.6	0.57	0.07
Length of pregnancy, days	116[ab]	114[b]	118[a]	0.69	0.01
Cycle of reproduction, days	177	173	177	1.00	0.06
No of litters/year	2.06	2.11	2.05	0.01	0.06

[ab] Mean values within rows with different superscript letters are significantly different (P<0.0)

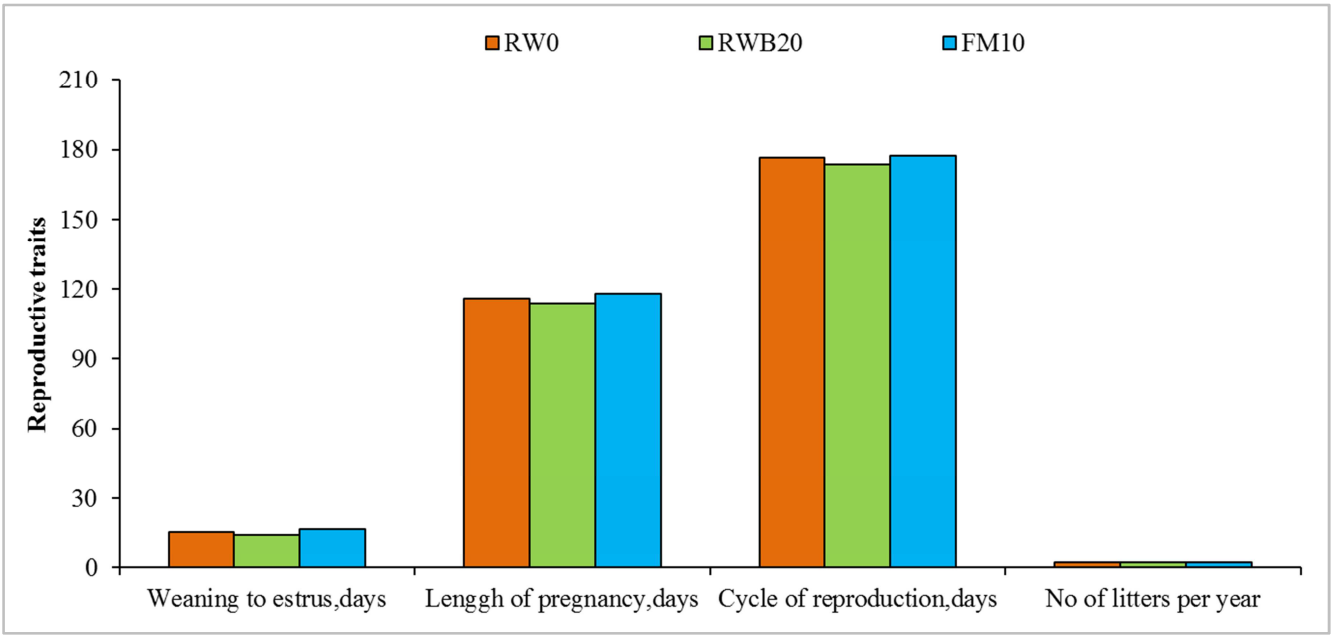

Figure 6. *Reproductive traits of sows fed the ensiled taro, rice wine by product and fish meal with a basal diet of rice bran.*

There were no effects among the treatments on parameters in weaning to estrus, cycle of reproduction and number of litters per year in term of reproduction traits, except for length of pregnancy was higher significantly different for RWB20 (Table 6, Figure 6). According to this finding of weaning to estrus was similar to those findings of Bounlerth et al (2010) [5], Chittavong et al (2008), and also similar to the reports of Tran Thanh Hai et al (2013) [8] on the parameters in weaning to estrus, cycle of reproduction and number of litters per year for reproductive traits. However, contrast results on parameter in weaning to estrus stage as fed the levels of sweet potato with fish meal, cassava meal, maize and rice bran. The different result is caused by using differences of feed ingredients when compared with the current findings.

4. Conclusions

A mixture of ensiled taro and rice wine by product plus fish meal fed basal diet of rice bran was increased the feed intake and crude protein in dry matter of sows in pregnancy and lactation.

Total litter size and mortality at birth and 21 days of ages were no effects among treatments. However, were higher increased at weaning 45 days of ages for treatment adding rice wine by product of 20% in the diet.

Weaning to estrus, cycle of reproduction and number of litters per year of sows was better for treatment fed a mixture of ensiled taro and rice wine by product plus fish meal fed basal diet of rice bran.

The overall conclusion showed a mixture of ensiled taro of 10% and rice wine by product of 20% were higher increased on feed intake of sows in pregnancy and lactation stages, higher increased on total litter size, total litter weight, litter weight change and mean piglet live weight of piglet performance during lactation period, and better effects in reproductive traits in weaning to estrus, cycle reproduction and number of litters per year.

As recommendation, the finding should be used to carry out for the next trial on the growth performance of fattening pigs by researchers and also should be highlighted and transferred that to the pig households at communities.

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