Evaluating Rice-Milling By-products and Palm Kernel Expeller as Alternative Feed Ingredients for Ayam Saga Chickens

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Abstract

The Malaysian poultry industry relies heavily on imported feed ingredients such as corn and soybean to fulfil the nutritional requirements for imported chicken breeds, such as Cobb and Ross. To address this, the Malaysian Agricultural Research and Development Institute (MARDI) introduced Ayam Saga, a chicken breed suited to local feed ingredients, which is high in fibre. This study evaluated growth, nutrient digestibility, carcass quality and economics of Ayam Saga chickens fed with rice-milling byproducts with a palm kernel expeller (PKE) based diet. Fifty 7-week-old grower Ayam Saga were randomly assigned to two dietary treatments with 25 per group: i) corn-soybean-based diet and ii) rice-milling-byproducts-based diet with 5% palm kernel expeller (PKE), both formulated to be isocaloric (~12 MJ/kg) and isonitrogenous (~19% crude protein). The study was conducted for five weeks. Performance results indicated that chickens fed the rice-milling-byproducts and PKE-based diet had lower feed intake (FI) but achieved similar weight gain and feed conversion ratio (FCR) as those on the corn-soy diet. Carcass analysis showed no significant differences in dressing percentage and thigh weight between the diets, although breast weight was significantly higher in the corn-soy group ($P < 0.0001$). A nutrient digestibility trial demonstrated that the rice-milling-byproducts and PKE-based diet had better apparent metabolizable energy (AME, 12.68 MJ/kg) and dry matter digestibility compared to the corn-soy diet (AME, 10.77 MJ/kg; $P < 0.0001$). These findings highlight the potential of rice-milling-byproducts and PKE as sustainable alternatives for local poultry production, without adverse effects on the performances. Further research is needed to refine the inclusion levels of these ingredients to maximize their benefits.

Keywords: Ayam Saga; growth performance; nutrient digestibility; palm kernel expeller; rice milling-byproducts

Introduction

The Malaysian poultry industry depends heavily on imported grandparent broiler breeds such as Ross and Cobb (Anon, 2019), as well as layer breeds, to meet the local demands and to achieve 100% country's self-sufficiency ratio (SSR) for

chicken meat and eggs. These imported chickens as well, consumed grain-based feed for energy and protein sources. Therefore, local feed mills import corn and soybean annually as main feedstuffs, especially from Argentina, Brazil and the United States. Over the past several years, the prices of these imported ingredients have continued to rise. Feeds account for 50 to 80% of total operational costs. Apart from that, due to world situation such pandemic and war, the possibility of sanction from importing country would affect food security in Malaysia, including the poultry industry.

Numerous studies have been conducted to evaluate the potential of local agriculture products and byproducts to be used as animal feed in Malaysia, such as byproducts from rice. It is well known that rice is a staple food for Malaysians, for their daily consumption. Data obtained from the Ministry of Agriculture and Food Security (MAFS, 2024) showed that the total rice planting area in 2023 was 614,082 hectares, which produced around 2.18 million mt of rice. Rice milling produces nearly 30% byproducts, such as bran, husk, and broken rice (Esa et al., 2013). Palm kernel expeller (PKE) is a byproduct from palm kernel oil extraction plants. Malaysia produces about 2.34 million mt of PKE in 2024 (MPOB, 2025). Rice byproducts and PKE contain high energy which allows these by-products to be turned into animal feed. Despite the potential benefits, most local ingredients have high fibre content, which makes them less suitable for chickens (Jha and Mishra, 2021).

Therefore, the Malaysian Agricultural Research and Development Institute (MARDI) through the Livestock Science Research Center has made an initiative by introducing a new chicken breed known as Ayam Saga that can adapt to local feed ingredients. This breed has similar characteristics as ayam Kampong (a native chicken breed), but their growth is faster and more uniform, with a weight of 1.5 - 1. 8 kg that can be reached by 10 to 12 weeks, compared to six months for ayam Kampong (MARDI, 2021). Further, Ayam Saga is well adapted to local environmental conditions (hot and humid climate) and can utilize local feed ingredients as alternatives to imported soybean and fishmeal. Replacement of these imported ingredients would help to reduce the cost of the feed price. Reducing feeding costs is important to help contribute to a competitive and sustainable poultry industry locally. Although rice-milling byproducts and PKE are widely available in Malaysia, their potential in Ayam Saga has not been fully evaluated. Rice-milling byproducts and PKE are well-documented as feed ingredients in other livestock species, as well as commercial broilers. However, their specific effects on growth performance and nutrient utilization in Ayam Saga remain underexplored. This lack of evidence restricts the ability to formulate cost-effective and sustainable feeding strategies suitable to the breed.

Therefore, this study aimed to determine the growth performance, nutrient digestibility, carcass quality, and economic viability of grower Ayam

Saga fed a rice-milling-byproducts and PKE-based diet.

Materials and Methods

Management and feeding trial of Ayam Saga

The experiment was conducted from April to May 2022 and received approval from the MARDI Animal Ethics Committee (AEC Approval 20210827/R/MAEC00092). A total of 50 Ayam Saga chickens were randomly divided into two treatments, with five replicates per treatment and five birds per replication pen (using 2-tier battery cages) in a completely randomized design. The birds were fed a commercial starter diet during the first four weeks after hatching. At the age of 5 and 6 weeks, the birds received a corn-soy-based diet formulated according to grower requirements to help them adapt to the treatment diets. The experiment began when the birds reached 7 weeks of age. Birds were assigned into two different diets. The treatment diets included: i) a corn-soy-based diet (Diet A) and ii) 31% of a rice-milling-byproducts-based diet with the addition of 5% PKE (Diet B). Rice milling byproducts comprised a mixture of broken rice, rice husk and rice bran. The diets were formulated to be isocaloric (metabolizable energy ~12 MJ/kg) and isonitrogenous (crude protein ~19.0%), as shown in Table 1. Feed and water were provided *ad libitum*.

Growth performance

Initial weights were recorded before the experiment started, and the birds were subsequently weighed every two weeks, as well as at the end of the experiment at week 12. Feed intake (FI) was also measured fortnightly. Average daily weight gain (ADG) and feed conversion ratio (FCR) were calculated based on body weight (BW) and FI. The FCR of birds was calculated as a ratio of total feed consumed to produce 1 kg of BW.

Carcass analysis

One bird from each cage of the treatments was slaughtered according to the halal procedure. The birds were then defeathered and eviscerated. Dressing percentage was calculated using equation 1.

Equation 1:

$$Dressing\ percentage = \frac{Weight\ of\ carcass}{Weight\ of\ live\ animal}\ 100$$

Cleaned carcasses (without head, internal organs and shanks) were weighed individually.

Then, carcasses were cut into parts. Thigh and breast were weighed separately. The yield for each part of the bird was then expressed as a percentage of the body weight.

Digestibility study

At the end of feeding trial (i.e., week 5 post-feeding), a total of 10 grower birds (12-weeks old) with five birds from each treatment were randomly selected and kept individually in 2-tier battery cages equipped with water drinkers and feeders in an enclosed house at MARDI Serdang. The birds were allocated to the same treatment diet: Diet A and diet B.

The study was conducted in five replicates per treatment, using a completely randomized design. All birds were fed treatment diets for 7 days of adaptation. Then, birds were fasted for one day prior to the experiment to empty their alimentary canal of feed residue. After that, birds were fed again with treatment diets. During the experimental period, FI was recorded and total excreta were collected for 3 days (Liu et al. 2022). Dried feed and excreta were analysed for dry matter and gross energy determination using a bomb calorimeter. These values will be then used to calculate the dry matter digestibility (DMD) and apparent metabolizable energy (AME) of the diets using the equation by Khalil et al. (2021).

Table 1. Ingredients and nutrient content of the corn-soy (Diet A) and treatment diet (Diet B)

Ingredient (%)	**Treatment**	
	Diet A	**Diet B**
Rice-milling byproducts	-	31.29
Corn	55.64	25.00
Soybean meal	25.00	15.00
Wheat pollard	11.00	11.00
Corn gluten	2.26	7.00
Palm kernel cake	-	5.00
Rice bran	1.05	-
Palm oil	1.00	2.00
Limestone	1.70	1.42
Di-calcium phosphate	1.00	1.00
Choline chloride	0.50	0.50
Salt	0.30	0.30
Lysine	0.31	0.26
Methionine	0.11	0.10
Mineral	0.10	0.10
Vitamin	0.03	0.03
Nutrient content (%)	**Diet A**	**Diet B**
Metabolizable energy, (by calculation, MJ/kg)	12.23	12.08
Gross energy (MJ/kg)	16.35	14.86
Crude protein (by calculation, %)	19.0	19.2
Crude protein (%)	18.93	17.91
Crude fibre (%)	3.24	4.00
Crude fat	2.79	2.01
Ash	4.93	6.39

[1]Diet A: corn-soybean-based diet
[2]Diet B: rice-milling-byproducts and PKE based diet

Feed cost

The price for feed ingredients used in the study was obtained from the feed industry. Feed cost analysis was conducted to calculate the cost of feed ingredients required to produce 1 kg of weight gain of Ayam Saga.

Statistical analysis

Data obtained were analysed by t-test using SAS Statistical Program ver9.3 (SAS, 2013). Significance was set at $P < 0.05$.

Results and Discussion

Performance of Ayam Saga

The growth performance results for Ayam Saga fed two (2) different treatment diets at growing stage are summarised in Table 2. The analysis showed that the diets had significant impacts ($P < 0.0001$) on all performance parameters measured, including weight gain, ADG, FI and FCR. Birds on the rice-milling-byproducts and PKE-based diet demonstrated higher performance compared to those on the corn-soy diet. Despite having lower feed intake (2.36 kg), birds from diet B gained higher weight gain (803.9 g/day) compared to diet A (689.8 g/day), resulting in an improved FCR for the group. Study on the effect of rice-milling-byproducts on native, slow growing chicken's performance is very limited as compared to commercial broilers. Onabanjo et al. (2021) reported no negative impact when rice-milling waste was included at levels up to 40% in diets for Arbor Acres chickens. However, Maikano (2012) observed that inclusion of this by-product at 20% reduced weight gain in birds by 4.6%. This reduction could be attributed to the higher crude fiber (CF) content of the diet they formulated (10.7%), whereas in this study the CF level was limited to a maximum of 5%.

Table 2. Growth performance (± SD) of grower Ayam Saga fed corn-soy and rice-milling-byproducts-PKE-based diets for 5 weeks

Treatments	Weight gain, g	[3]ADG (g/day)	[4]FI (kg)	[5]FCR
[1]Diet A	689.8 ± 43.00	19.71 ± 1.23	2.72 ± 0.14	3.95 ± 0.30
[2]Diet B	803.8 ± 72.39	22.97 ± 2.07	2.36 ± 0.12	2.95 ± 0.19
P-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Means differ significantly ($P < 0.05$; *t*-test)
[1]Diet A: corn-soybean-based diet
[2]Diet B: rice-milling-byproducts and PKE based diet
[3]ADG: average daily gain; [4]FI: feed intake, [5]FCR: feed conversion ratio

Findings from studies on other rice by-products are also discussed. Rezaei et al. (2006) studied the effect of broken rice (BR) on broiler performance, and found that the use of BR up to 50% in broiler diets did not statistically effect feed intake and body weight gain, but improved FCR ($P < 0.05$) of the birds. Tariq et al. (2019) reported similar observations in their study, with no significant effect on the body weight was observed at any growth stage of the birds fed diet formulated with broken rice. However, Kratzer et al. (1974) and Gallinger et al. (2004) showed a decline in broiler performance over the range of 20% rice bran in the diet. This could be because their study incorporated rice bran in the diet, while our study used a mixture of rice-milling by-products, including rice bran, rice husk, broken rice, and other fractions. Rice bran contains anti-nutritional factors (ANF), such as phytic acid, tannins, saponins,

and phenolic compounds (Irakli et al. 2020), that can interfere with nutrient absorption (Isah and Okusun, 2023). For example, high level of phytic acid in feed can lead to mineral deficiencies, as it binds important mineral like calcium, iron and zinc making them less available for absorption (Gupta et al., 2013). Apart from that, rice bran also contains high insoluble dietary fibre (IDF) which limits the use of this ingredient in poultry feed (Isah and Okusun, 2023). IDF is poorly digested in poultry because chickens lack the necessary enzymes to break down complex fibrous structures like cellulose, hemicellulose, and lignin. It can also encapsulate starch, protein, and fat, making these nutrients less accessible for digestion, further limiting feed efficiency (Jha and Mishra, 2021). Therefore, the use of mixed rice by-products could help reduce growth retardation associated with ANF and IDF. Another reason could be due to the type of chicken used in the experiment. Ayam Saga is a slowly-growing, local native chicken breed. According to Ginindza et al. (2017), Thamaga et al. (2021) and Cui et al. (2022), native chicken could tolerate feeds containing high levels of dietary fibre and anti-nutritional factors (ANFs), owing to their adaptive digestive physiology, diverse gut microbiota, and lower nutrient requirements compared to commercial broilers.

Similar to PKE, which contains high fibre. Our findings also indicated that incorporating 5% PKE did not negatively affect the digestibility for Ayam Saga. Previous studies, such as Zahari and Alimon (2005), had suggested that PKE could be included in chicken diets up to 20%. They noted that including more than 30% PKE in commercial broiler diets could impair energy utilization due to high fibre content. Moreover, native chickens show strong tolerance to high-fibre feeds, as mentioned above.

Both rice milling-byproducts and PKE are high in fibre. High fibre reduces diet palatability and increases gut fill, leading to lower voluntary feed intake, as shown in the feed intake results. The presence of ANFs in rice byproducts as well could limit the intake. Nevertheless, the reduced intake did not adversely affect weight gain. This could be due to the slow digesta transit of fibre, which prolongs nutrient absorption time and thereby improves feed efficiency despite lower intake (Mateos et al. 2012; Jha and Mishra, 2021). However, further research is necessary to determine the optimal levels of PKE and rice-milling-byproducts for slow-growing chickens, as nutrient absorption and utilization may depend on the birds' genotype (Pym, 1995).

Carcass yield

In terms of carcass analysis, data were collected for dressing percentage, thigh weight, and breast weight (Table 3). All parameters showed significant differences ($P < 0.0001$) between the treatment groups. These results aligned with the weight gain of the birds, as previously described. The results of this study demonstrated significant improvements in the carcass yield of Ayam Saga chickens fed a diet containing rice-milling-byproducts and PKE. It is suggested that these ingredients

enhanced the efficiency of feed utilization and deposition into carcass. Similarly, Onabanjo et al. (2021) reported comparable findings in birds fed diets containing 10–40% rice-milling by-products, particularly in terms of thigh yield, although the differences between treatments in their study were not statistically significant.

The study by Abidah and Wan Nooraida (2017) showed that broilers fed a diet containing 10% PKE had a higher carcass yield compared to those fed a corn–soy–based diet, however, the differences were not significant. Despite the lack of prior research directly examining the effects of rice-milling-byproducts on carcass yield, the findings indicated promising outcomes that warrant further investigation. The ability of Ayam Saga to efficiently utilize nutrients from these ingredients could be attributed to the breed's adaptation to local feed resources, as suggested by Pym (1995). This characteristic makes Ayam Saga suitable for sustainable poultry production in regions with limited access to conventional feed ingredients.

Table 3. Carcass yield of Ayam Saga fed corn-soy and rice-milling-byproducts-PKE-based diets

Treatments	Dressing percentage, %	Thigh, g	Breast, g
[1]Diet A	69.08 ± 2.04	59.70 ± 7.46	84.73 ± 10.50
[2]Diet B	71.03 ± 2.37	73.30 ± 9.01	111.21 ± 10.14
P-value	<0.0001	<0.0001	<0.0001

[1]Diet A: corn-soybean-based diet
[2]Diet B: rice-milling-byproducts and PKE based diet

Nutrient digestibility

Diet incorporating rice-milling-byproducts-PKE (Diet B) showed significantly higher AME (12.68 MJ/kg, $P < 0.0001$) compared to the corn-soybean based diet (Diet A) of 10.77, which is presented in Table 4. The higher AME observed in Diet B could be attributed to the relatively higher starch content, which is highly digestible, in rice byproducts compared to corn–soybean diets. Starch concentration and digestibility could have an impact on the metabolizable energy values (Svihus et al., 2005; Wang et al., 2017, Xie et al., 2021). However, starch content was not analysed in this experiment. Future work should therefore include starch quantification to validate this assumption.

A similar trend was observed in the digestibility rate of dry matter, where Diet B demonstrated higher digestibility for Ayam Saga compared to Diet A. The findings of this study revealed that the inclusion of rice-milling-byproducts and 5% PKE did not adversely affect the digestibility of Ayam Saga. Some studies

had suggested that PKE could be incorporated in chicken diets up to 20% (Zahari and Alimon, 2005). Zahari and Alimon (2005) reported that incorporating more than 30% PKE in the diet of commercial broiler chickens would lead to a deficiency in energy utilization, attributed to the high fibre content. These results highlight that Ayam Saga has high tolerance to high-fibre diets, a trait that distinguishes it from commercial broiler breeds reliant on low-fibre feedstuffs.

Table 4. Dry matter digestibility (%, ± SD) and apparent metabolizable energy (MJ/kg, ± SD) of corn-soybean (Diet A) and rice-milling-byproducts-PKE (Diet B) based diets

Treatment diet	[3]DMD (%)	[4]AME (MJ/kg)
[1]Diet A	70.52 ± 3.01	10.77 ± 0.62
[2]Diet B	71.63 ± 1.76	12.68 ± 0.37
P-value	< 0.0001	< 0.0001

[1]Diet A: corn-soybean-based diet

[2]Diet B: rice-milling-byproducts and PKE based diet

[3]DMD-dry matter digestibility, [4]AME-apparent metabolizable energy

Feed ingredient cost

The cost of raw materials for producing 1 kg of Ayam Saga on a rice-milling-byproducts-PKE-based diet during the growing period was lower than that of a corn-soy-based diet, amounting to RM 8.00 and RM 9.20, respectively. This represents a 13% reduction in feed cost. Improved bird performance due to better feed quality could enhance revenue from the birds.

Conclusion

This study demonstrates that the inclusion of rice-milling byproducts supplemented with palm kernel expeller (PKE) can effectively support growth, nutrient digestibility, and carcass yield in Ayam Saga chickens, while also reducing feed costs compared to conventional corn–soy diets. The results highlight the unique adaptability of Ayam Saga to fibre-rich local feed resources, a characteristic that sets it apart from imported broiler breeds and strengthens its role as a sustainable alternative for Malaysia's poultry industry. Beyond the nutritional and economic benefits, the ability to utilize locally available byproducts directly contributes to national strategies for reducing dependency on imported feedstuffs and improving food security. Further work should focus on optimizing inclusion levels and validating these results at commercial scale, but the present findings clearly position Ayam Saga as a resilient and cost-effective option for sustainable poultry production in tropical environments.

optimized conditions reinforces the feasibility of utilizing agro-industrial residues such as palm kernel expeller (PKE) as cost-effective substrates for microbial phytase production. This strategy supports sustainable animal nutrition by reducing dependence on inorganic phosphate supplements and aligning with environmental

conservation goals (Elkhateeb & Fadel, 2022; Rizwanuddin et al., 2023).

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