Research Article

# Diffusion Model of Leguminous Plants Enzyme-Based Formulated Feeds for Hogs

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**Abstract** | The cost of commercial feed is increasing, this was considered the most expensive component in hog enterprise. Leguminous-based feeds as an alternative source of protein-rich hog feed are promising since these are the cheapest. T0 with 100% commercial feeds (CF), T1 with 50% CF and 50% Leguminous Plants Enzyme Based Formulated Feeds (LPEBFF), and T2 with 100% LPEBFF. 27 heads were distributed in three different hog industries, each industry has allocated 9 heads of hog. T2 displayed a significant crude protein content with a gradual decrease in its crude fiber content. Weight of hogs between CF and LPEBFF with a p-value of <0.001. The correlation was significant, since the p-value was <0.05 significance level. There was a significant difference in the growth performance of hogs. T0 and T1 incurred higher costs than the income, resulted to a net loss, while T2 has a positive net income. T0 and T1 achieved a negative profit across industries, since the costs of commercial feeds were high, while T2 attained a positive result across 3 industries with good profit. Scores of meat quality consistently rise from T0 to T2, culminating in a mean score of 5.96 in T2 signifying a favorable result in the overall evaluation. Moreover, the research findings have led to the development of a diffusion model known as the Marcos Bollido Technology (MBT), which has the potential to benefit the hog industry by offering locally formulated feeds that are more cost-effective, healthier, and improving the quality of meat.

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## Introduction

A significant change in the global livestock industry is occurring at the same time as advancements in animal feed formulas. As the demand for meat, dairy, and other animal products rises globally, there is a greater focus on optimizing the nutritional content of animal feeds to improve the health, productivity, and overall performance of livestock.

This trend is especially noticeable in developing nations like South America and the Asia Pacific where rising levels of urbanization and net pay are encouraging people to eat more animal protein.

The Philippines hog production industry is a complicated one with many players at various levels and in various sectors. This sector, which includes both commercial and private farms and contributes significantly to the national economy, has distinct operational sizes and features (Lassaletta *et al*., 2019).

The estimated number of hogs in the nation as of March 31, 2023, was 10.18 million. Compared to the 9.77 million heads counted in 2022, this indicates a 4.2% increase. Smallholder farms produced roughly 76.5 percent of the nation's swine population, with commercial and semi-commercial farms producing the remaining 22.3 percent and 1.2 percent of the total swine population being unreported (PSA, 2023).

The livestock industry and hog farming in particular is at a pivotal juncture in its history, when the effective use of feed resources is critical to both the financial sustainability of the sector and the health of the animals. As worries about the consequences of present feed formulations on human health and the environment mount, there is a huge need for innovation.

Leguminous plants are essential to sustainable agriculture because they can fix atmospheric nitrogen, which improves soil quality and reduces the need for synthetic fertilizers (Saikita *et al*., 2020). Leguminous plant utilization in animal feed formulations has garnered a lot of interest recently, particularly in the hog industry. The cost of commercial animal feed has increased over the past few years, making the feeding system the biggest challenge facing farmers and business in the hog-rearing process (Vidad *et al*., 2022).

The hog industry's adoption of Leguminous Plants Enzyme Based Formulated Feeds (LPEBFF) is essential for improving animal nutrition, promoting economic growth, and ensuring environmental sustainability. By lowering feed costs, improving livestock health, and minimizing the environmental effects of conventional feed sources, LPEBFF adoption has the potential to significantly boost the economy (Reckling *et al*., 2016).

The goal of this project was to create a technological diffusion model for the Samar hog industry called leguminous plant enzyme based formulated feed (LPEBFF). The local farmer hog raisers and hog industries in Samar will be introduced to the proposed LPEBFF diffusion model for their use of plant-based feeds.

According to Kambashi's (2014) analysis, there is a global need for concentrated feed resources is rising, particularly in tropical areas where many nations import food on a net basis. Using forage plants as a substitute presents a number of challenges, despite the fact that they are higher in fiber and plant secondary metabolites and have a lesser nutritional value.

It is anticipated that feed costs in 2023 will be roughly 1 to 3 percent higher than those in 2022, according to Langemeier (2020). Since 2007, the average feed cost index has been 90.9. The feed index for 2022 is predicted to be 123.3, while the average feed cost index for the final quarter of 2022 is predicted to fall between 134 and 136.

According to the study of Fortina *et al*. (2011) findings indicated that pasture-based swine management requires less inputs, it should be particularly appealing to farmers with limited resources. Half of the animal's nutritional requirements can be met by pasture, reducing grain costs without sacrificing carcass quality.

According to the study of Bollido *et al*., (2021); Barroga (2014) Native pigs given madre de aqua and kitchen leftover show notable improvements in growth and piglet production.

In the solid-state fermentation (SSF) of *Trichoderma harzianum* BiomaTH1 and Y lipolytica W29, the amount of crude protein increased dramatically from 12.0% to 15.29% and 14.06% dry matter (DM), respectively. The primary source of protein and necessary amino acids for animal feed was raised by 55% and 22% DM, respectively. Fungi and yeast were used to increase the in vitro protein digestibility of dried distiller's grain (DDG) derived from fermented cassava from 82.5% to 89.2% and 86.9% (Siada *et al*., 2018).

Due to the presence of all the typical ruminal bacteria in their large intestine microflora, hogs, particularly adult pigs, are better able to use dietary fiber than humans. Pig production and consumption have been found to be affected by a number of supply chain problems, such as low-quality meat from private slaughterhouses, backyard farms' high risk of disease, and a shortage of yellow maize (Fang and Elca, 2021).

The necessity of establishing leguminous plantations is in line with the demands of the industry and farmers, indicating a dramatic change in the hog business toward efficient and sustainable farming methods. The strong demand for pork in Eastern Visayas, especially in Samar, which is 940 tons annually, has proven too much for our companies and local farmer-raisers to supply (Bollido *et al*., 2022).

There are forage species that can be utilized as protein sources, such as monogastric farm animals like hogs in the tropics. Innovative approaches must be used to incorporate forage-based feed choices for monogastric animals into existing smallholder systems. There are gaps in our understanding of the impacts of feeding as well as the crude or total protein digestibility of plants (Smith *et al*., 2014).

Despite the fact that pork is in high demand and makes a substantial economic contribution, many customers select organic products because they wish to reduce their exposure to pesticides present in commercial goods that are caused by hog commercial feed. A substantial deterioration in immune system function, an increase in infant mortality, and other health problems have been connected to the use of chemicals, antibiotics, and hormones, in addition to certain sexual dysfunctions, malignancies, and allergy sensitivity (Gopalakrishnan, 2019).

Consuming pork from pigs on legume-based diets has been linked in studies to lower cholesterol, better cardiovascular health, and a decreased chance of developing chronic illnesses including diabetes and some types of cancer (Long *et al*., 2020). Furthermore, in terms of lowering greenhouse gas emissions and conserving land and water, legume-based feeds have demonstrated potential in addressing environmental issues related to conventional feed production (Afonso *et al*., 2022).

Commercial feeds contain antibiotics and growth hormones, and organically grown animals are not fed made from animal byproducts. People who engage in organic farming appear to enjoy the best possible health and have a lower risk of developing chronic diseases (Gopalakrishnan, 2019; Hurtado-Barroso *et al*., 2019).

Despite being the most popular meat in the world, pork is among the most harmful. Any customer should be aware of the serious and little-discussed risks it carries. These problems make it challenging to identify the health risks associated with hog-derived products and assess whether they are safe to eat (Nanji and French, 1985).

Hog meat's high fat and cholesterol content aggravates cardiovascular problems in humans. A diet high in fat raises a person's risk of developing large intestine cancer, according to epidemiological research (Qamar and Raza, 2012).

In livestock value chains, creative business models can help coordinate markets for inputs, services, outputs, expertise, and talents (Kebebe, 2019). Farmers with longer extension visits, more group activities, and training programs for both farmers and extension agents had better adoption indexes (Jara-Rojas *et al*., 2020; Dhraief *et al*., 2019; Onegi, 2018).

This study addresses this pressing need by introducing the novel concept of Leguminous Plants Enzyme-Based Formulated Feeds (LPEBBF) tailored specifically for the hog industry. Thus, aims to validate and diffuse nutrient content of LPEBFF; comparative analysis of LPEBFF versus commercial feeds; growth performance of hogs; cost of feeds, meat quality produced in terms of tenderness, color, appearance (fat thickness), flavor, design and develop a technology diffusion model based on the result of the study, and to produce diffusion model product.

## Materials and Methods

*Research design*

Using a quantitative research methodology, the study employed an experimental and descriptive research design. The study's pre-experimental involved building a hog house. Measuring 0.5 by 1.20 meters and 1.10 meters in height, the individual pigpen had these dimensions. While nine (9) pigpens were built for each piggery in this industry-scale research.

The process of making legume grasses started with gathering fresh leaves, cutting them into medium-sized pieces, putting them in a container, mixing the chopped leaves with molasses, and applying a fungus called *Trichoderma harzianum,* which produced an enzyme that was shown to be effective and active in breaking down fiber. Using distilled water, potato, agar, and dextrose powder as medium, the pathogenicity of *Trichoderma harzianum* was examined in a lab setting. After seven days, sterile water was added, and the cultures were gently scraped with a sterile wire loop. 15 kg of fresh and chopped legume leaves were combined with the stock spore suspensions in sterile beakers containing 300 ml of water dilution. A hemacytometer was used to estimate the total spore concentration, which came out to be $8.0\times10^{9}$.

To prevent air from entering, the mixture was sealed within the container and allowed to cure for 15 days. Samples of the legumes were taken while they were curing and sent to the Department of Agriculture Laboratory Center in Tacloban city, Leyte, Philippines, for nutrient laboratory analysis.

**Table 1:** *Industry scale experimental dedign.*

| Industry | T0 100% CF | Ani. Code | T1 50% CF and 50% LPEBFF | Ani. Code | T2 100% LPEBFF | Ani. code |
|---|---|---|---|---|---|---|
| A | | 1 | | 4 | | 7 |
| | | 2 | | 5 | | 8 |
| | | 3 | | 6 | | 9 |
| B | | 10 | | 13 | | 16 |
| | | 11 | | 14 | | 17 |
| | | 12 | | 15 | | 18 |
| C | | 19 | | 22 | | 25 |
| | | 20 | | 23 | | 26 |
| | | 21 | | 24 | | 27 |

*CF- Commercial Feeds, Ani. code- Animal code, T0-Treatment 0, T1- Treatment 1, and T2- Treatment 2.*

Twenty-seven (27) heads of the same breed of fattener hog were distributed to three (3) different hog industries. There were nine (9) heads of hogs in every industry. The hog industries were marked as A, B, and C (Table 1).

*Research environment*

The industry research scale was located at Barangay Aurora, with two (2) industries and Brgy. Mabuhay, San Jorge, Samar, with one (1) industry.

*Feeding management*

To adapt to the new feed type, the experimental hogs were fed a three-day standard gradual feeding procedure: 25% LPEBFF + CF on the first day, 50% LPEBFF + 50% CF on the second day, and 75% LPEBFF + 25% CF on the third day. The following days were spent following the recommended amount and type of feeds in each treatment.

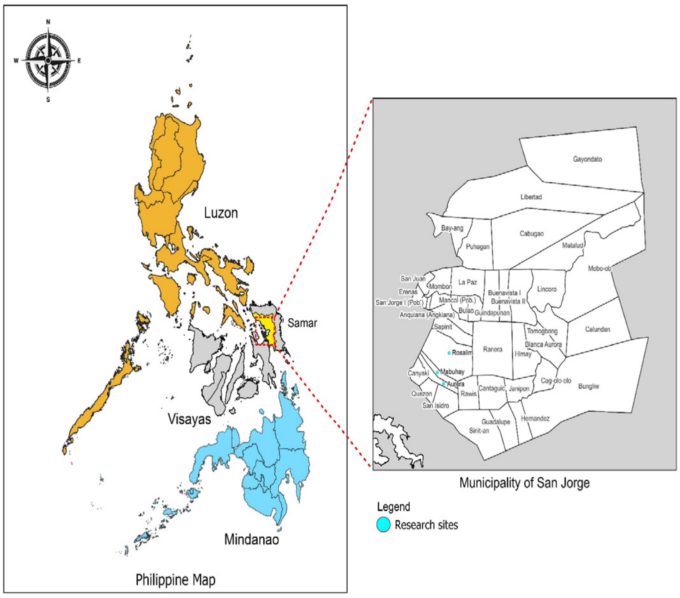


**Figure 1:** *Geo-reference map of the research area.*

The hogs were fed a restricted type of diet consisting of LPEBFF and commercial feeds every morning and afternoon following three (3) days of gradual feeding. They had unlimited access to water. Ninety days after weaning, the animals were fed. Pigs from the weaning age to the fattener age were fed twice a day for three (3) months. Pigs were butchered after the study. The feeding plan used commercial feed from hog pre-starter (0.5 kilogram daily for 10 days), hog starter (1.25 kg daily for 20 days), hog grower (1.75 kg daily for 40 days), and hog finisher (2.30 kg daily for 20 days).

According to the research experimental design, the experimental hogs were also provided Leguminous Plants Enzyme Based Formulated Feeds (LPEBFF) in proportion to the quantity of commercial feeds. Throughout the trial, the feeding guide matrix (Table 2) was closely adhered to.

**Table 2:** *Feeding guide for hogs.*

| Age (days) | Approx. weight (kg) | Days of feeding | Ave. daily feed consumption (kg) |
|---|---|---|---|
| 40-50 | 14-22 | 10 | 0.50 |
| 50-70 | 22-35 | 20 | 1.25 |
| 70-110 | 35-55 | 40 | 1.75 |
| 110-130 | 55-80 | 20 | 2.30 |

*Kg- Kilogram, Ave.- Average.*

*Data gathering procedure*

Fresh legume plants, particularly Flemingia and Indigofera, were gathered from the grazing areas of the Department of Agriculture's Southern Leyte

Research Experiment Stations in Malitbog and Sogod on the campus. The legume leaves were cut into little pieces after being removed off the twigs and placed in the container. Leguminous Plant Enzyme Based Formulated Feeds (LPEBFF) for hogs were made with 81.97% legume leaves, 5.46% molasses, 10.93% water, and 1.64% *Trichoderma harzianum*.

The hogs were routinely observed by the researcher for growth, health, and feeding practices. Each week, the weight of the hogs was measured. Significant data was collected following the 90-day experimental period in the areas of nutrient content enzyme evaluation, comparison of LPEBFF with commercial feeds, hog growth performance, feed costs, and meat quality as measured by tenderness, color, appearance (fat thickness), and flavor. Meat flavor is influenced by a variety of elements, including temperature, pH, protein, fats, glycogen, fatty acids, marbling, and cooking techniques.

A database of the hog industry was created in the research environment's key site. To confirm the precise quantity of hogs grown and to identify sows and gilts that had farrowed and weaned piglets within the target start of the research industry investigation, about seven (7) industries were visited.

Seven (7) industries were selected to provide consulting and information sharing regarding the LPEBFF technology, its industry-level research operation, the advantages of utilizing the technology, and the creation of Memorandum Of Understanding (MOU) between the researcher and the piggery owner. Three (3) of the seven (7) industries that were revisited expressed a positive willingness to adopt and use LPEBFF and its research activities.

As shown in Table 3, the age, breed, gender, and weight of the weaned piglets for industry scale were similar to that of the experimental hogs used in laboratory scale.

*Statistical treatment of data*

All observations in each parameter were subjected to Analysis of Variance (ANOVA) in a Randomized Complete Block Design (RCBD). The researcher also used the Statistical Package for the Social Sciences (SPSS). Treatment means with significant or highly significant differences were compared using Bonferroni analysis at a 5% level of significance.

**Table 3:** *Validation and diffusion of technology in industry scale.*

| Industry code | Animal ID | Weight | Age (day) | Sex | Breed |
|---|---|---|---|---|---|
| A | 1 | 6.80 | 45 | Female | LWB |
| | 2 | 6.00 | 45 | Female | LWB |
| | 3 | 6.70 | 45 | Female | LWB |
| | 4 | 7.21 | 45 | Female | LWB |
| | 5 | 7.40 | 45 | Female | LWB |
| | 6 | 7.40 | 45 | Female | LWB |
| | 7 | 7.50 | 45 | Female | LWB |
| | 8 | 7.35 | 45 | Female | LWB |
| | 9 | 7.10 | 45 | Female | LWB |
| B | 1 | 7.20 | 45 | Female | LWB |
| | 2 | 6.90 | 45 | Female | LWB |
| | 3 | 6.50 | 45 | Female | LWB |
| | 4 | 6.40 | 45 | Female | LWB |
| | 5 | 6.60 | 45 | Female | LWB |
| | 6 | 7.10 | 45 | Female | LWB |
| | 7 | 6.80 | 45 | Female | LWB |
| | 8 | 6.25 | 45 | Female | LWB |
| | 9 | 6.70 | 45 | Female | LWB |
| C | 1 | 6.10 | 45 | Female | LWB |
| | 2 | 6.90 | 45 | Female | LWB |
| | 3 | 7.80 | 45 | Female | LWB |
| | 4 | 7.50 | 45 | Female | LWB |
| | 5 | 7.30 | 45 | Female | LWB |
| | 6 | 7.65 | 45 | Female | LWB |
| | 7 | 7.70 | 45 | Female | LWB |
| | 8 | 7.16 | 45 | Female | LWB |
| | 9 | 7.12 | 45 | Female | LWB |

*LWB- Large White Breed, ID- Identification.*

## Results and Discussion

*Validation and diffusion of LPEBFF*

Industry-scale validation and dissemination of the study were carried out. Evaluation of the nutrient content of LPEBFF, comparison of LPEBFF with commercial feeds, growth performance, and feed cost were the factors that were employed in the validation and diffusion process.

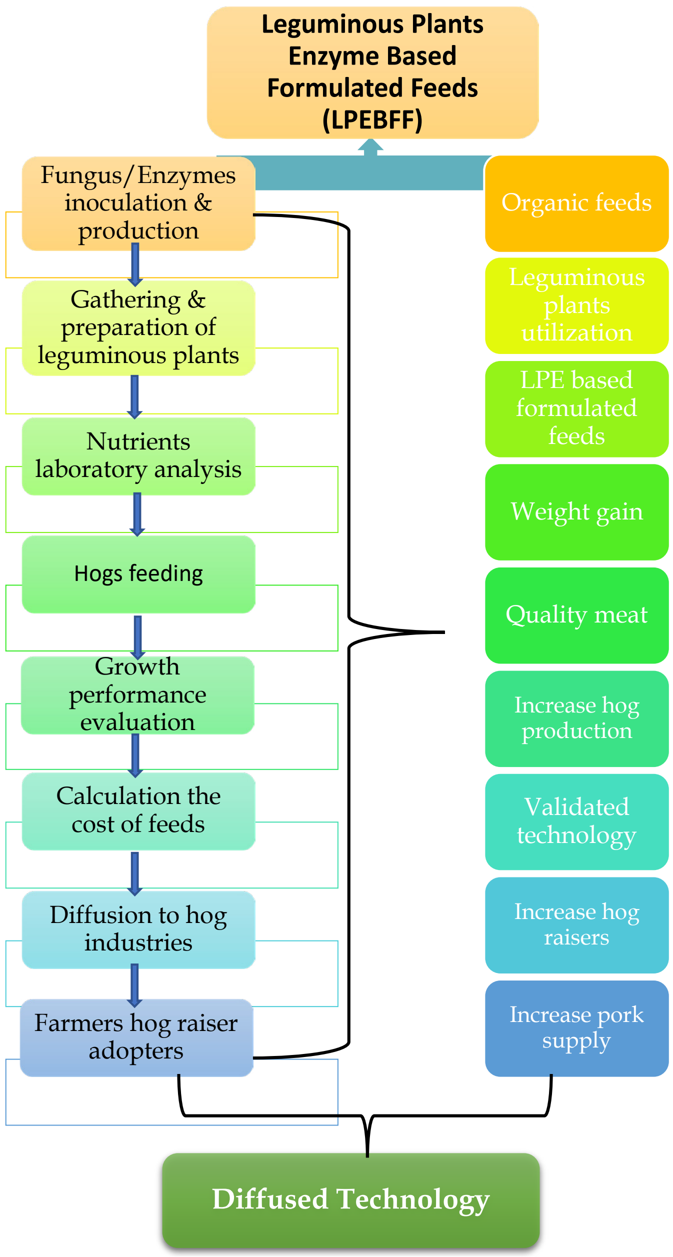


**Figure 2:** *Formulation and development of feeds.*

**Table 4:** *Industry scale nutrient content evaluation (%).*

| Nutrients | T0 100% CF | T1 50% LPEBFF and 50% CF | T2 100% LPEBFF |
|---|---|---|---|
| Crude fat | 5.50 | 11.34 | 17.18 |
| Crude protein | 16.00 | 19.74 | 23.47 |
| Crude fat | 3.00 | 1.88 | 0.76 |
| Calcium | 0.80 | 1.55 | 2.29 |
| Phosphorous | 0.70 | 0.50 | 0.29 |

*T0-Treatment 0, T1- Treatment 1, and T2- Treatment 2, CF- Commercial Feeds, LPEBFF- Leguminous Plants Enzyme Based Formulated Feeds*

The nutrients used in laboratory-scale study were the same as those found in various feeds used in industry. Using the filter bag technique and AOCS-approved procedures Ba6a-05, the legume plant was analyzed in a lab for crude fiber. The results showed a noticeable drop in the fiber content of several samples (Table 4). This demonstrates that the fiber of legume grasses can be broken down by the fungus *Trichoderma harzianum*. Compared to T1 (11.73%) and T2 (17.96%), the crude fiber in T0 was reduced by 5.60 percent.

**Table 5:** *Nutrient comparative analysis of CF and LPEBFF in industry scale (%).*

| Nutrients | 100% LPEBFF | 100% CF | CV |
|---|---|---|---|
| Crude fiber | 17.96a | 5.50b | 4.34 |
| Crude protein | 22.79a | 16.00b | 2.50 |
| Crude fat | 0.78b | 3.00a | 0.7483 |
| Calcium | 2.37a | 0.80b | 3.28 |
| Phosphorous | 0.31b | 0.70a | 2.80 |

*Means with the same letter designation are not significantly different at a 5% level of significance. CV- Coefficient of Variance, a- signifies the highest value while b- signifies the lowest value, CF- Commercial Feeds, LPEBFF- Leguminous Plants Enzyme Based Formulated Feeds*

The experimental data showed that LPEBFF had higher levels of crude fiber, crude protein, and calcium than commercial feeds, but lower levels of crude fat and phosphorus (Table 5). According to Hlatini *et al*. (2018), leguminous leaf meals are a valuable feed ingredient for pigs due to their high availability and relatively high crude protein content. On the other hand, Oyaniran *et al*. (2018) found that the crude protein content of the legumes they studied exceeded the minimum recommended range. According to Juknevičius *et al*. (2007), the nutritional contents of a grown leguminous plant (Fabaceae) showed higher accumulations of Ca, Mg, Cu, Zn, Mn, Fe, and Co.

The study conducted by Yu *et al*. (2019) showed that hogs fed a high-fiber diet released more nitrogen from their faces. This result is in line with the study's findings, which indicate that the LPEBFF has substantial levels of crude fiber and crude protein. There should be enough nitrogen left over in the animal feces if the animal feed is properly prepared. Urinary nitrogen levels were lower in low-protein diets than in normal diets and high-fiber diets. Eating a meal lower in protein and higher in fiber reduced nitrogen excretion.

According to Zhao *et al*. (2023) consuming a diet rich in fiber can enhance growth performance, safeguard gut health, or the beneficial bacteria in the digestive system, and increase digestive efficiency. Pigs digestive tracts may benefit from a high-fiber diet as a safe and efficient dietary approach to preserving beneficial microorganisms.

In addition to its nutritional benefits, LPEBFF contains a high amount of fiber, which is essential for the animal's body to absorb calcium for skeletal development. A study by Wu *et al.* (2022) found that consuming a diet high in fiber helped the body absorb calcium far more easily. Dietary fiber of 85% improved calcium absorption in the body, which may be important for maintaining bone health during a period of rapid bone growth.

The study of Jha and Berrocoso (2015) dietary fiber is linked to lower net energy values and a decreased ability to utilize nutrients. To maintain the digestive system's physiological function, fiber must be ingested through the diet. Furthermore, dietary fiber's detrimental impacts will vary widely depending on its characteristics.

**Table 6:** *Cost of feeds in industry scale (PhP).*

| Particular (Expenses per head) | Industry A | | | Industry B | | | Industry C | | |
|---|---|---|---|---|---|---|---|---|---|
| | T0 | T1 | T2 | T0 | T1 | T2 | T0 | T1 | T2 |
| Feeds | 6,980.75 | 3,835.00 | 730.00 | 6,477.50 | 3,350.00 | 730.00 | 6,890.00 | 3,333.00 | 730.00 |
| Labor | 3,000.00 | 3,000.00 | 3,000.00 | 3,000.00 | 3,000.00 | 3,000.00 | 3,000.00 | 3,000.00 | 3,000.00 |
| Piglet | 4,000.00 | 4,000.00 | 4,000.00 | 4,000.00 | 4,000.00 | 4,000.00 | 4,000.00 | 4,000.00 | 4,000.00 |
| **Total Expenses** | **13,980.75** | **10,835.00** | **7,730.00** | **13,477.50** | **10,350.00** | **7,730.00** | **13,890.00** | **10,333.00** | **7,730.00** |
| Income (per head) | 12,895.00 | 9,780.00 | 8,859.00 | 12,869.00 | 9,798.00 | 8,960.00 | 12,458.00 | 9,784.00 | 8,979.00 |
| **Total Income** | **12,895.00** | **9,780.00** | **8,859.00** | **12,869.00** | **9,798.00** | **8,960.00** | **12,458.00** | **9,784.00** | **8,979.00** |
| **Profit** | *- 1,085.75* | *- 1,055.00* | *1,129.00* | *- 608.50* | *- 552.00* | *1,230.00* | *- 1,432.00* | *- 549.00* | *1,249.00* |

*T0- 100% CF, T1- 50% CF and 50% LPEBFF, T2- 100% LPEBFF, T0-Treatment 0, T1- Treatment 1, and T2- Treatment 2.*

The results showed that T0, which used just commercial feeds, had greater operational costs than the other treatments across all industries (Table 6). But T0 was the one with the largest total income, followed by T1 and T2.

Table 6 shows that T0 and T1 experienced a net loss since their expenses exceeded their income, however T2 showed a positive net profit. T0 achieved -1,085.75 in Industry A, -608.50 in Industry B, and -1,432.00 in Industry C. Similarly, T1 made -1,055.00 in Industry A, -552.00 in Industry B, and -549.00 in Industry C with negative profits. These were brought about by the high costs of commercial feeds. However, since T2 had the cheapest feed, it resulted a very good profit. T2 attained a positive profit of 1,129.00 in Industry A, 1,230.00 in Industry B, and 1,249.00 in Industry C. The result validates the similar findings of Penjor *et al.* (2022) highlighting the cost benefit analysis which showed higher net return from piglets fed with Azolla pinnata plant substitution. Feeding of sweet potato silage reduces feed costs up to 40% (Lukuyu *et al*., 2017).

*Evaluation of the meat quality produced*

Tenderness, color, flavor, look, and fat thickness were all used to assess the quality of the meat that was produced. The meat quality generated using these settings is displayed in Table 7.

**Table 7:** *Meat quality in terms of tenderness, color, and flavor.*

| Meat quality parameters | T0 | | T1 | | T2 | |
|---|---|---|---|---|---|---|
| | Mean | Median | Mean | Median | Mean | Median |
| **Tenderness** | | | | | | |
| Description | 3.07 | 3 | 3.11 | 3 | 2.96 | 3 |
| Acceptability | 5.15 | 6 | 5.7 | 6 | 5.78 | 6 |
| **Color** | | | | | | |
| Description | 4.31 | 4 | 4.69 | 5 | 5.23 | 5 |
| Acceptability | 4.31 | 4 | 4.54 | 5 | 4.77 | 5 |
| **Flavor** | | | | | | |
| Description | 2.81 | 3 | 2.85 | 3 | 3.07 | 3 |
| Acceptability | 5.19 | 5 | 5.3 | 6 | 5.63 | 6 |
| General acceptability | 5.37 | 5 | 5.78 | 6 | 5.96 | 6 |

*T0- 100% CF, T1-50% CF and 50% LPEBFF, T2-100% LPEBFF, T0-Treatment 0, T1-Treatment 1, T2- Treatment 2*

The sensory assessments of pork were conducted in the food technology laboratory room with 27 panelists who had established the general acceptability, color, flavor, and softness of the meat, as well as its description and acceptability (Table 7). Meat quality is largely determined by softness, which varies somewhat between treatments. T1 had the highest mean tenderness score, 3.11.

The meat's overall tenderness has improved, as seen by the upward trend in the acceptability of tenderness, which reached 5.78 in T2. The pattern for color description and acceptability is similar, with scores progressively rising for each treatment. Indicating a favorable influence on the meat's sensory qualities, flavor measurements also show an increased tendency. The overall acceptability scores steadily increase from T0 to T2, reaching a mean score of 5.96 in T2, which indicates a positive assessment overall.

Findings from similar research are consistent with the reported improvements in meat quality. For instance, research on alternative feed sources for pigs by Renaudeau *et al*. (2022) on alternate feed sources for pigs highlights the possible influence of dietary components on meat quality parameters. According to the study, feeding hogs leguminous leaf meals may improve their growth and protein intake, which will result in higher-quality pork.

Higher levels of flavor, color, softness, and overall acceptance are associated with Leguminous Plant Enzyme Based Formulated Feeds (LPEBFF). The upward trajectory of these metrics highlights the possible advantages of using novel feed formulations, highlighting the significance of balanced nutrition in hog production for higher-quality meat.

*Appearance and fat thickness*

Figure 3, Tables 8 and 9 show the meat appearance and fat thickness, respectively.


**Figure 3:** *Appearance of meat quality.*

In T0, the average thickness of the meat was greater than that of T1 and T2. The pork in treatments 0, 1, and 2, on the other hand, showed comparable results in terms of fat thickness (Figure 3). This study's findings are consistent with a study by Zmudzińska *et al*. (2020) that found that fattening hogs fed legume plants and extracted rapeseed meal (RSM) were significantly less fat than control hogs. Regarding the five measurements of fat thickness, there were notable variations between the animals fed the soybean meal (SBM) diet of 2.26 cm and those fed the RSM diet supplemented with legume plants of 1.99 cm.

The comparison of meat thickness and appearance between LPEBFF and 100% commercial feeds yielded a p-value of <0.001, as shown in Table 8. With a p-value below of <0.05 significance level, the correlation is significant. Therefore, the hypothesis that there is no significant difference in the quality of hog meat based on its thickness is rejected.

**Table 8:** *Meat appearance and thickness.*

| Treatment | Mean meat thickness (cm) | SE | P |
|---|---|---|---|
| 0 (100% CF) | 13.50 | 0.0289 | |
| 1 (50% CF and 50% LPEBFF) | 11.30 | 0.0273 | |
| 2 (100% LPEBFF) | 10.00 | 0.0393 | |
| | | | < .001 |

*SE- Standard Error, P- p-value or probability value, T0-Treatment 0, T1-Treatment 1, T2- Treatment 2*

The comparison of fat thickness between LPEBFF and 100% commercial feeds yielded a p-value of <0.001, as indicated in Table 9. With a p-value of <0.05 significance level. So, the hypothesis that there is no substantial difference in the quality of meat as to the fat thickness of pork, is rejected. Contrast of significant differences among the growth performance, quality meat, and cost of LPEBFF and CF.

**Table 9:** *Meat quality fat thickness.*

| Treatment | Mean fat thickness (cm) | SE | P |
|---|---|---|---|
| 0 (100% CF) | 2.40 | 0..00882 | |
| 1 (50% CF and 50% LPEBFF) | 2.10 | 0.01764 | |
| 2 (100% LPEBFF) | 1.05 | 0.01155 | |
| | | | < .001 |

*SE- Standard Error, P- p-value or probability value, T0-Treatment 0, T1-Treatment 1, T2- Treatment 2 cm- Centimeter, LPEBFF- Leguminous Plants Enzyme Based Formulated Feeds.*

**Table 10:** *Comparisons of the weight of hogs in industry scale.*

| | Sum of squares | DF | MS | F | P |
|---|---|---|---|---|---|
| Industry | 3.22 | 2 | 1.61 | 0.506 | 0.611 |
| Treatment | 9622.25 | 2 | 4811.13 | 1511.259 | <.001 |
| Industry and treatment | 14.02 | 4 | 3.51 | 1.101 | 0.386 |
| Residuals | 57.30 | 18 | 3.18 | | |

*DF- Degrees of Freedom, MS- Mean Square, F- F statistics ratio of two variances, P- p-value or probability value*

The ANOVA in Table 10 indicates that the mean hog weights for the three industries do not differ significantly (F= 0.506, p= 0.611). This leads to the rejection of the null hypothesis, which states that there are no notable side effects from the medication. According to Tukey's significant difference test, hogs with treatment 0 have the highest mean weights, which is consistent across industries. However, hogs with treatment 2 have the lowest mean weights (Table 11).

**Table 11:** *Industry scale comparison of treatment.*

| Treatments | | Mean difference | SE | DF | Ptukey |
|---|---|---|---|---|---|
| 0 | 1 | 19.50 | 0.841 | 18.0 | <.001 |
| 0 | 2 | 46.10 | 0.841 | 18.0 | <.001 |
| 1 | 2 | 26.60 | 0.841 | 18.0 | <.001 |

*Comparisons are based on estimated marginal means, SE- Standard Error, DF- Degrees of Freedom. T0- 100% CF, T1- 50% CF and 50% LPEBFF, T2- 100% LPEBFF, T0-Treatment 0, T1-Treatment 1, T2- Treatment 2*

The relationship between two sets of data is statistically significant according to Tukey's test because the means were significantly different from one another (<0.001) based on the comparison of treatments (Table 11).

**Table 12:** *Comparisons of meat acceptability.*

| Treatment | Mean difference | P-value |
|---|---|---|
| T0 – T1 | 1.657 | 0.104 |
| T0 – T2 | 2.268 | 0.028 |
| T1 – T2 | 0.611 | 0.544 |

*T0- 100% CF, T1- 50% CF and 50% LPEBFF, T2- 100% LPEBFF, T0-Treatment 0, T1-Treatment 1, T2- Treatment 2.*

A comparison of the general acceptability of pork between 100% commercial feeds and LPEBFF was found, with a p-value of 0.028, as shown in Table 12. Given that the p-value is less than the significance criterion of 0.05, the correlation is significant. Therefore, the hypothesis that there is no significant difference among the quality of meat regarding the overall acceptability of pig is rejected.

*The model*

Marcos Bollido Technology (MBT) was innovated to support the hog industry, which includes those who raise hogs in their backyards. The costly commercial feeds, which account for nearly 70% of the costs associated with raising hogs, is currently one of the most pressing issues. The MBT is a cheap organic feed made of a mixture of leguminous plants, molasses, water, and *Trichoderma harzianum* fungus to break down fibers and help the hogs become accustomed to eating 100% fresh legume grass feeds.

The preparation of legume grasses begins with the collection of fresh leaves, chopping them into medium pieces, stocking them within the container, adding molasses to the chopped leaves, application of fungus *Trichoderma harzianum* that produces an enzyme which is proven good and active in degrading fiber. Pathogenicity of *Trichoderma harzianum* under laboratory conditions using potato, agar, dextrose powder, and distilled water as media, in 7-day cultures are added with sterile water and carefully scraped with a sterile wire loop. The stock spores' suspensions are placed in sterile beakers with 300 ml water dilution, with the total spore's concentration estimated to $8.0 \times 10^9$ using a hemacytometer and mixed with 15 kgs of fresh and shopped legume leaves. The mixture is sealed in the container to avoid air entrance, and curing the mixture for 15 days. While the legumes are under curing it is subjected to nutrient laboratory analysis at the Department of Agriculture Laboratory Center, Tacloban City, Leyte, Philippines.

The quantity of the ingredients in producing the Leguminous Plant Enzyme Based Formulated Feeds (LPEBFF) for hogs was 81.97% legume leaves 5.46% molasses, 10.93% water, and 1.64% *Trichoderma harzianum*.

In addition to providing hog industries and backyard hog farmers with special legumes based formulated feeds, the MBT will also produce pork that is beneficial to human health. The mass production of MBT will generate jobs and farmers will enjoy an increased revenue from the planting of legume grasses which is an added value of MBT.

Early Adopters, influential figures within the community, may follow suit and act as opinion leaders. As positive outcomes become apparent, the early majority, representing a broader segment of the industry, may start adopting MBT, leading to a tipping point. The Late Majority, more cautious in their approach, follows suit, influenced by the growing acceptance of MBT. Lastly, Laggards, characterized by traditional practices and reluctance to change, eventually adopt MBT under external pressures.

The model also emphasizes the role of communication channels, social systems, perceived attributes of the innovation, and the rate of adoption in influencing this process. By applying Rogers' Diffusion of Innovations theory, the study gains a structured framework to understand and facilitate the successful diffusion of

MBT in the hog industry.

Innovators are typically the first individuals to adopt an innovation. In this context, industry A, B, and C are considered innovators who have taken the initial step of adopting MBT for hog feeding. These individuals are considered risk-takers and early experimenters in the context of hog farming.

Early adopters follow the innovators and act as influential figures within the community. In this case, industries D, E, F, and G are indirectly adopting MBT. They are influenced by the positive outcomes observed in the practices of the innovators. The model suggests that, over time, a broader segment of the industry, represented by the early majority and late majority, may start adopting MBT.

This could be a gradual process as positive results become more apparent and acceptance grows within the community. Laggards, characterized by traditional practices and reluctance to change, may eventually adopt MBT under external pressures. While no specific individuals are listed as laggards in the provided data, they could emerge as external factors influencing even those resistant to change. The model emphasizes the role of communication channels and social systems. In this context, communication between adopters, word-of-mouth recommendations, and the influence of influential figures (early adopters) play a crucial role in the diffusion process.

The success of the diffusion process depends on how the adopters perceive the attributes of the innovation. Positive outcomes and benefits observed in hog farming practices using MBT will contribute to its successful adoption.

The model also considers the rate of adoption. The data does not explicitly provide information on the rate, but the categorization of adopters (direct and indirect) suggests an ongoing process of adoption within the hog industry.

The MBT diffusion model framework, as illustrated in Figure 4, began with an experiment in which four heads of hog fatteners were fed legume grasses grown in the backyard. In addition to producing meat of superior quality and reaching good growth performance, hogs also allowed farmers to save money on the cost of buying commercial feed.

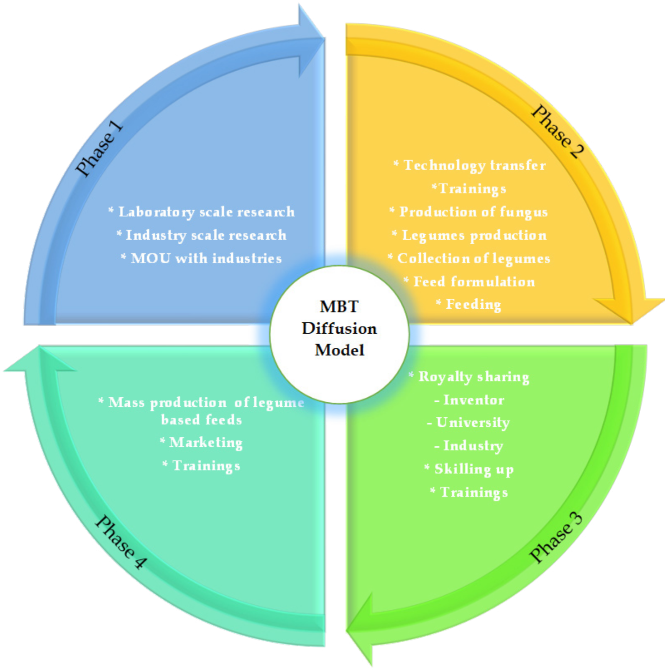


**Figure 4:** *The MBT diffusion model framework.*

The researcher conducted laboratory and industry scale researches as part of the diffusion model, which included validation and diffusion of the technology. This was combined with an agreement with industry owners for the diffusion and validation of the technology. Formulated policies of different industry, Local Government Unit (LGU), and university stakeholders will genuinely guarantee MBT adoption.

The model encompasses the development of human capital for those directly involved in the commercialization of MBT, as well as stakeholders and industries that will utilize the technology. For a model to be considered sustainable, it must guarantee that farmers can establish legume grass plantations as the primary source of MBT product.

Additionally, the model will guarantee that the inventor, university, and industry will all receive their royalties in accordance with the laws established by the university and the Philippine Intellectual Property Office. In order to handle customer feedback and product enhancements, the model will be subject to innovation and skill development. The commercialization aspect of the model will involve mass production of MBT in order to meet the market's demand for supply.

The proposed action plan for technology transfer (Table 13) is intended to evaluate MBT and offer a summary of the next measures to improve its adoption.

This plan describes the individuals and groups participating in the process, their roles, the actions they take, and the results they hope to achieve in order to ensure the adoption and utilization of MBT. The action plan is helpful because it provides a framework for considering the effective implementation of MBT. This ensures that tasks are completed in a logical order and that no important steps are missed out.

**Table 13:** *Technology transfer action plan.*

| Activities | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 | Y7 | Y8 | Y9 | Y10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Series of consultation meeting with industry owner | 5,000 | | | | | | | | | |
| Laboratory scale research | 100,000 | | | | | | | | | |
| Industry scale research | 120,00 | | | | | | | | | |
| Forging MOA with University, LGU & industry owner (include royalty sharing) | 5,000 | | | | | | | | | |
| Conduct training in hog production and Feed formulation using the MBT | 10,000 | | | | | | | | | |
| Preparation of inoculant media | 8,000 | | | | | | | | | |
| Inoculation of fungus *T. harzianum* | 5,000 | | | | | | | | | |
| Gathering of legume leaves | 2,000 | | | | | | | | | |
| Chopping of legume leaves | 1,000 | | | | | | | | | |
| Mixing of legume leaves with fungus and other ingredients | 1,000 | | | | | | | | | |
| Storage of formulated MBT | 8,000 | | | | | | | | | |
| Identification of farmers for plantation of legumes | 1,000 | | | | | | | | | |
| Farmers consultation for the establishment of legume plantation | 8,000 | | | | | | | | | |
| Land preparation | 10,000 | | | | | | | | | |
| Nursery establishment | 5,000 | | | | | | | | | |
| Sowing and potting of legumes | 5,000 | | | | | | | | | |
| Planting of legumes | 100,000 | | | | | | | | | |
| Policies of institution, LGU & industries for technology adoption | | | 5,000 | | | | | | | |
| Transfer of MBT innovation | 10,000 | | | | | | | | | |
| Mass production of legume based feeds for hogs | | | | 1,000,000 | | | | | | |
| Construction of feed formulation laboratory | 3,000,000 | | | | | | | | | |
| Research and innovation/upskilling | | | 1,500,000 | | | | | | | |

## Conclusions and Recommendations

- The study has undertaken a comprehensive exploration of Marcos Bollido Technology (MBT) in hog farming, revealing multifaceted insights into its production, economic viability, and impact on hog growth and meat quality. The dynamic fluctuations observed in key nutrient parameters during the production of MBT with fungi as enzymes highlight the refining process involved, emphasizing the potential of MBT as a valuable nutrient source for hogs.
- While hogs fed with 100% commercial feeds exhibited superior growth, the introduction of MBT showed promising results in terms of meat quality, with improvements observed in tenderness, color, flavor, and general acceptability. These positive trends align with related studies, emphasizing the importance of well-balanced nutrition in hog production for superior meat quality. Moreover, the adoption and diffusion model based on Rogers' theory provides a structured framework for understanding the potential pathways for the integration of MBT in hog industry.
- The economic analysis, comparing MBT with commercial feeds, emphasizes the favorable financial outcome associated with the exclusive use of MBT, suggesting its potential to contribute positively to the financial sustainability of hog-raising operations. Furthermore, the production of MBT will create employment and will give livelihood opportunities to the farmers in the production of legume grasses.
- MBT has the potential to offer a holistic solution in the hog industry, providing healthier, economical, valuable, and affordable locally-formulated feeds to enhance hogs' growth and meat quality. As the industry seeks sustainable and innovative practices, the study lays a foundation for further research and adoption of MBT, encouraging stakeholders to consider alternative feed formulations that align with both economic and nutritional purposes.
- Stakeholders in the hog industry are encouraged to consider the exclusive adoption of MBT, as indicated by the favorable economic outcomes associated with its use. This may involve transitioning from conventional commercial feeds to enjoy the benefits of MBT in terms of cost-effectiveness and financial sustainability;
- Effective communication strategies should be employed to disseminate the use of MBT among hog farmers, emphasizing its nutritional advantages and economic viability. Proper information dissemination technique will faciltate the adoption of the technology as an institutionalized policy of the university, Local Government Unit, and industry;
- Further research is recommended to delve into the specific mechanisms like the addition of micronutrients to formulated feeds that would influence the improvements of growth and meat quality associated with MBT.
- Ongoing monitoring and evaluation of hog performance, economic indicators, and meat

quality parameters are crucial to continually refine and adopt MBT formulations. This adaptive approach will ensure the ongoing success of this innovative feed solution within the dynamic context of hog farming;

- Hog farmers should allocate a portion of land for the plantation of legume grasses to guarantee a stable supply of raw materials for the production of MBT
- Collaboration between researchers, policymakers, and industry stakeholders is essential to create a supportive environment for the integration of MBT. This includes addressing potential challenges related to market dynamics, and regulatory frameworks, and ensuring the alignment of MBT with evolving consumer preferences and emerging industry standards.

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## Novelty Statement

The formulation of Leguminous Plants Enzyme Based Formulated Feeds using legume grasses. These grasses were applied *Trichoderma harzianum* to degrade or lower the fiber content to benefit monogastric animals like hog. The research findings have led to the development of a diffusion model known as the Marcos Bollido Technology (MBT), which has the potential to benefit the hog industry by offering locally formulated feeds that are more cost-effective, healthier, and more valuable while improving the growth and quality of meat.

*Conflict of interest*

The author has declared no conflict of interests regarding the publication of this article.

## References

Afonso, A., E.S.D. Cruz, I.S. Pereira, M.D. Napoleão and C.N. Nabais. 2022. The efficiency of leguminoceae production grains plus maize as a feeding on growth phase of local swine (*Potamochoerus porcus*) in Timor-Leste. J. Petern. Indonesia (Indones. J. Anim. Sci.), 24(2): 215-224. https://doi.org/10.25077/jpi.24.2.215-224.2022

Barroga, A.J., 2014. A dynamic Philippine swine industry: The key to meeting challenges and technological innovations.

Bollido, M.E., E.G. Espejon Jr, L.R. Horca, L.E.B. Mante and F.R. Bejar. 2021. Native swine production feed with kitchen leftover and madre de aqua (*Trichantera gigantea*). J. Aust. Soc. Agric. Econ., 17(4): 433-441.

Bollido, M.E., R.J.G. Villaluz and R.L. Orale. 2022. Emerging supply chain of pork and the opportunities for small scale raisers in Catbalogan city in the Philippines. Sarhad J. Agric., 38(4). https://doi.org/10.17582/journal.sja/2022/38.4.1370.1380

Dhraief, M.Z., S. Bedhiaf, B. Dhehibi, M. Oueslati-Zlaoui, O. Jebali and S. Ben-Youssef. 2019. Factors affecting innovative technologies adoption by livestock holders in arid area of Tunisia. New Medit. Mediterr. J. Econ. Agric. Environ. Rev. Méditerr. d'Econ. Agric. Environ., (4). https://doi.org/10.30682/nm1904a

Fang, C.P.L. and C.D. Elca. 2021. An assessment of swine industry in the Philippines. J. Econ. Manage. Agric. Dev., 7(2390-2022-797): 21-48.

Fortina, R., A. Brugiapaglia, S. Tassone, V. Malfatto and A. Cavallero. 2011. Pasture-based swine management: Behavior and performances of growing-finishing pigs. Sci. Pap. Anim. Sci. Biotechnol., 44(1): 37-40.

Gopalakrishnan, R., 2019. Advantages and nutritional value of organic food on human health. Int. J. Trend Sci. Res. Dev., 3(4): 242-245. https://doi.org/10.31142/ijtsrd23661

Hlatini, V.A., C.N. Ncobela, T.J. Zindove and M. Chimonyo. 2018. Use of polyethylene glycol to improve the utilisation of leguminous leaf meals in pigs: A review. S. Afr. J. Anim. Sci., 48(4): 609-620. https://doi.org/10.4314/sajas.v48i4.2

Hurtado-Barroso, S., A. Tresserra-Rimbau, A. Vallverdú-Queralt and R.M. Lamuela-Raventós. 2019. Organic food and the impact on human health. Crit. Rev. Food Sci. Nutr., 59(4): 704-714. https://doi.org/10.1080/10408398.2017.1394815

Jara-Rojas, R., R. Canales, J.M. Gil, A. Engler, B.

Bravo-Ureta and C. Bopp. 2020. Technology adoption and extension strategies in Mediterranean agriculture: The case of family farms in Chile. Agronomy, 10(5): 692. https://doi.org/10.3390/agronomy10050692

Jha, R. and J.D. Berrocoso. 2015. Dietary fiber utilization and its effects on physiological functions and gut health of swine. Animal, 9(9): 1441-1452. https://doi.org/10.1017/S1751731115000919

Juknevičius, S. and N. Sabienė. 2007. The content of mineral elements in some grasses and legumes. Ekologija, 53(1).

Kambashi-Mutiaka, B., 2014. Assessing tropical forage species used as pig feed ingredients in the western provinces of the Democratic Republic of the Congo (Doctoral dissertation, Université de Liège, Liège, Belgique). https://doi.org/10.1016/j.anifeedsci.2014.01.012

Kebebe, E., 2019. Bridging technology adoption gaps in livestock sector in Ethiopia: A innovation system perspective. Technol. Soc., 57: 30-37. https://doi.org/10.1016/j.techsoc.2018.12.002

Langemeier, M., 2020. Prospects for Swine Feed Costs in 2021. Farmdoc Daily, 10(207).

Lassaletta, L., F. Estellés, A.H. Beusen, L. Bouwman, S. Calvet, H.J. Van Grinsven and H. Westhoek. 2019. Future global pig production systems according to the shared socioeconomic pathways. Sci. Total Environ., 665: 739-751. https://doi.org/10.1016/j.scitotenv.2019.02.079

Long, S., S. Liu, D. Wu, S. Mahfuz and X. Piao. 2020. Effects of dietary fatty acids from different sources on growth performance, meat quality, muscle fatty acid deposition, and antioxidant capacity in broilers. Animals, 10(3): 508. https://doi.org/10.3390/ani10030508

Lukuyu, B., P. Lule, B. Kawuma and E. Ouma. 2017. Feeds and forage interventions in the smallholder pig value chain of Uganda. ILRI (aka ILCA and ILRAD).

Nanji, A. and S. French. 1985. Relationship between pork consumption and cirrhosis. Lancet, 325(8430): 681-683. https://doi.org/10.1016/S0140-6736(85)91338-8

Onegi, B., 2018. Factors limiting technology adoption: a case study of feeding concentrate feeds to pigs among pig farmers in Panyango sub-county, Pakwach district (Doctoral dissertation, Busitema University).

Oyaniran, D.K., V.O.A. Ojo, R.Y. Aderinboye, B.A. Bakare and J.A. Olanite. 2018. Effect of pelleting on nutritive quality of forage legumes. Livest. Res. Rural Dev., 30(4): 75.

Penjor, T., P. Sherab, G. Tsheten and S. Penjor. 2022. Comparative performance of weaner pigs fed commercial feed and Azolla Pinnata as feed substitute. Bhutan J. Anim. Sci., 6(1): 22-27.

Philippine Statistics Authority (PSA). 2023. Swine Situation Report, January to March. Retrieved from https://psa.gov.ph/livestock-poultry-iprs/swine/inventory.

Qamar, M.F. and I. Raza. 2012. Scientific evidences that pig meat (Pork) is prohibited for human health. Sci. Pap. D. Anim. Sci., 55.

Reckling, M., G. Bergkvist, C.A. Watson, F.L. Stoddard, P.M. Zander, R.L. Walker and J. Bachinger. 2016. Trade-offs between economic and environmental impacts of introducing legumes into cropping systems. Front. Plant Sci., 7: 669. https://doi.org/10.3389/fpls.2016.00669

Renaudeau, D., S.K. Jensen, M. Ambye-Jensen, S. Adler, P. Bani, E. Juncker and L. Stødkilde. 2022. Nutritional values of forage-legume-based silages and protein concentrates for growing pigs. Animal, 16(7): 100572. https://doi.org/10.1016/j.animal.2022.100572

Saikia, P., A. Nag, S. Anurag, S. Chatterjee and M.L. Khan. 2020. Tropical legumes: Status, distribution, biology and importance. The plant family fabaceae: Biology and physiological responses to environmental stresses, pp. 27-41. https://doi.org/10.1007/978-981-15-4752-2_2

Siada, O.A.A., M.S. Negm, M.E. Basiouny, M.A. Fouad and S. Elagroudy. 2018. Protein enrichment of agro–industrial waste by Trichoderma harzianum EMCC 540 through solid-state fermentation for use as animal feed. J. Geogr. Environ. Earth Sci. Int., 13(4): 1-12. https://doi.org/10.9734/JGEESI/2017/39019

Smith, J., C.L. Gerrard and J.E. Hermansen. 2014. Improved contribution of local feed to support 100% Organic feed supply to pigs and poultry.

Vidad, A.J.P., N.T. Bugtai and R.K.C. Billones. 2022. Cost minimization of locally available hog feeds for backyard hog raising. In 2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM) (pp. 1-6). IEEE. https://doi.org/10.1109/HNICEM57413.2022.10109549

Wu, K.C., S. Cao, C.M. Weaver, N.J. King, S. Patel, H. Kingma and A.L. Schafer. 2022. Prebiotic to improve calcium absorption in postmenopausal women after gastric bypass: A randomized controlled trial. J. Clin. Endocrinol. Metab., 107(4): 1053-1064. https://doi.org/10.1210/clinem/dgab883

Yu, D., W. Zhu and S. Hang. 2019. Effects of low-protein diet on the intestinal morphology, digestive enzyme activity, blood urea nitrogen, and gut microbiota and metabolites in weaned pigs. Arch. Anim. Nutr., 73(4): 287-305. https://doi.org/10.1080/1745039X.2019.1614849

Zhao, Y., C. Liu, J. Niu, Z. Cui, X. Zhao, W. Li and G. Cao. 2023. Impacts of dietary fiber level on growth performance, apparent digestibility, intestinal development, and colonic microbiota and metabolome of pigs. J. Anim. Sci., 101: skad174. https://doi.org/10.1093/jas/skad174

Zmudzińska, A., B. Bigorowski, M. Banaszak, A. Roślewska, M. Adamski and M. Hejdysz. 2020. The effect of a diet based on legume seeds and rapeseed meal on pig performance and meat quality. Animals, 10(6): 1084. https://doi.org/10.3390/ani10061084