



Technology Validation of Leguminous Plants Enzyme-based Formulated Feeds for Hog Industries

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ABSTRACT

Background: This study aims to validate Leguminous Plants Enzyme Based Formulated Feeds (LPEBFF) nutrient content; comparative analysis of LPEBFF versus Commercial Feeds (CF); growth performance of hogs; cost of feeds; meat quality and to determine the significant difference among hogs in terms of growth performance, quality of meat and cost using the LPEBFF and commercial feeds.

Methods: The study utilized an experimental and descriptive research design using a quantitative research method. T0 with 100% CF, T1 50% CF and 50% LPEBFF and T2 100% LPEBFF. Nine heads of hog were allocated in the study.

Result: T2 displayed a significant crude protein content while a gradual decrease in its crude fiber content occurred subsequently. In T0 hogs achieved the highest mean weight of 60.32 kg, followed by T1 36.44 kg and T2 19.31 kg. T0 with 100% CF, shows the highest total expenses, amounting to 11,452.66, as compared to T1 8,956.33 and T2 6,463.33. Positive profit for T2 740.84, with potential financial benefit. In contrast, both T0 and T1 show negative profits, indicating financial losses. General acceptability of meat quality consistently rises from T0 to T2, culminating in the mean score of 5.96 in T2 signifying a favorable result in the overall evaluation. Meat quality on appearance and thickness between CF and LPEBFF <0.001 was obtained and the correlation is significant <0.05 favorable in T2.

Key words: Commercial feeds, Enzyme, Hog industry, Leguminous plant, Meat quality.

INTRODUCTION

Developments in animal feed formulations are coinciding with a major shift in the global livestock business. To improve the health, productivity and general performance of livestock, there is a greater emphasis on maximizing the nutritional content of animal feeds as the demand for meat, dairy and other animal products rise globally.

As of March 31, 2023, the country's total hog population was projected 10.18 million heads. This represents a 4.2% increase over the 9.77 million heads accounted in 2022. (PSA, 2023).

The local industry market is confident in its hog products since Filipino consumers favor warm and fresh pork over frozen one (Barroga, 2014). High input costs, especially for feeds, are considered a serious problem by most hog or pig farmers. This problem of the hog farmers is affecting their business substantially (Galano, 2020). Leguminous plants are vital to sustainable agriculture because they can fix nitrogen from the atmosphere, improving the soil and lowering the need for artificial fertilizers (Saikita *et al.*, 2020).

Crossbred grower pigs can tolerate up to 20% dietary substitution of maize with banana pseudostem in the ration without compromising their growth (Baruah *et al.*, 2024). Sweet potato meal similarly to indigofera and flemingia containing high in fiber can be used in place of 75% of the concentrate combination in the ration of native-growing pigs without negatively affecting their ability to grow and use nutrients (Malsawmthangi *et al.*, 2016). Our industries and local farmer-raisers have not been able to meet the high demand for pork, which is 940 tons per year in Eastern

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Visayas (Bollido *et al.*, 2022) and Pigs are very much suitable to the small pig farmers with low input production system for livelihood and sustainable pig farming.

The utilization of plant fiber feed for hogs can be improved by using various techniques and may be improved by breeding for enhanced fiber utilization (Lindberg, 2014). Pig hindgut bacteria have the ability to ferment and digest dietary fibre in the intestines of pigs, improving the structure of intestinal microflora, lowering the incidence of intestinal illnesses and promoting the healthy growth of pigs (Hussein *et al.*, 2021), but Kambashi *et al.* (2014), however, disagreed, arguing that pigs' capacity to recover nutrients from fiber is hampered by their caecotrophic behaviour and lack of foregut fermentation. Poor growth performance in pigs is caused by nutritionally imbalanced diets.

Fed with legume-based diets may contribute to reduced cholesterol levels, improved cardiovascular health

and lowered risk of chronic diseases such as diabetes and certain cancers (Long *et al.*, 2020). Commercial feeds contain growth hormones, 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).

Processed pork should be considered carcinogenic to humans, the development of colorectal cancer (Lippi *et al.*, 2016; Johnson, 2017; Qamar and Raza, 2012). A better comprehension of the risks that such drugs pose to human health is essential for regulatory decisions and programs that support the responsible nonhuman use of hormonal drugs and antibiotics (Jeong *et al.*, 2010).

This study aims to validate LPEBFF nutrient content; comparative analysis of LPEBFF versus commercial feeds; growth performance; cost of feeds; meat quality and to determine the significant difference among hogs in terms of growth performance, quality of meat and feed cost.

MATERIALS AND METHODS

Research design

The study utilized an experimental and descriptive research design on a quantitative research method conducted in Northwest Samar State University, San Jorge Campus, Philipinbes, on February 2024. The pre-experimental of the study was the construction of a hog house. The individual pigpen measured 0.5 meters by 1.20 meters with 1.10 meters in height. Nine pigpens were constructed for the research study. A total of nine (9) large white breed female hogs, weaned at 45 days after farrowing, with an average initial body weight of 6-10 kgs were assigned and placed randomly into three (3) treatments with three (3) replications for the laboratory scale of the study.

The preparation of legume grasses began with the collection of fresh leaves, chopped into medium pieces, stocked them within the container, adding molasses to the chopped leaves and applying of fungus *Trichoderma harzianum* that produced enzyme that was proven good and active in degrading fiber. Pathogenicity of *T. harzianum* under laboratory conditions using potato, agar, dextrose powder and distilled water as media, in 7-day cultures were added with sterile water and carefully scraped with a sterile wire loop.

The stock spores' suspensions were placed in sterile beakers with 300 ml water dilution, with the total spore's concentration estimated to 8.0×10^9 using a hemacytometer and mixed with 15 kgs of fresh and shopped legume leaves. The mixture was sealed in the container to avoid air entrance and curing the mixture for 15 days. While the legumes were under curing process, samples of these were collected and subjected to nutrient laboratory analysis at the Department of Agriculture Laboratory Center.

Feeding management

Hogs were given feeds using restricted type of feeding with LPEBFF and CF everyone morning and afternoon.

The animals were fed within 90 days after weaning. After the duration of the study, pigs were slaughtered. Feeding followed a scheme using the commercial feeding from hog pre-starter with 0.50 kg per day in 10 days, hog starter with 1.25 kg per 20 days, hog grower with 1.75 kg per day in 40 days and hog finisher with 2.30 kg per day in 20 days.

Similarly, the experimental hogs were fed with the LPEBFF proportional to the amount of commercial feeds as stated in the research experimental design.

Data gathering procedure

Fresh flemingia and Indigofera were collected. Leaves were removed from twigs, chopped into small pieces and put the chopped legume leaves in the container.

After the experimental period of 90 days significant data were gathered in terms of nutrient content enzyme evaluation; 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) and flavor. The LPEBFF was subjected to laboratory analysis for crude fiber, crude protein, crude fat, calcium and phosphorus using the filter bag technique, AOCS approved procedures Ba6a-05 by the Department of Agriculture Laboratory Division, while CF was based on the nutritional facts provided by manufacturer.

Statistical treatment of data

Analysis of Variance (ANOVA) in a randomized complete block design (RCBD). The researcher also used the Statistical Package for the Social Sciences (SPSS) and Statistical Tool for Agricultural Research (STAR). Treatment means with significant or highly significant differences were compared using Bonferroni analysis at a 5% level of significance.

RESULTS AND DISCUSSION

Validation of LPEBFF

Table 1 shows fluctuations in key parameters such as crude protein, crude fat, crude fiber, calcium and phosphorus. Notably, indigofera and flemingia, displayed a significant crude protein content, emphasizing its potential as a valuable nutrient source. Additionally, the gradual decrease in crude fiber content in subsequent samples suggests a refining process in the production of fungi as enzymes, indicating an improvement in the feed's digestibility over time. All samples further exhibited a consistent reduction in crude fiber, reinforcing the efficacy of the processing method.

The data in Table 1 underscores the dynamic nature of the production process, revealing trends that align with the optimization of nutrient content in the Leguminous Plants Enzyme Based Formulated Feeds (LPEBFF). The progressive increase in crude protein, coupled with a reduction in crude fiber, suggests an enhancement in the feed's nutritional quality. The variations in calcium and

phosphorus content also reflect the formulation adjustments made during the production stages.

As cited in previous research on feed optimization, these trends align with the principles of refining feed formulations to achieve desirable nutritional outcomes for livestock (Lancheros *et al.*, 2022). This variability in nutrient content within the Leguminous Plants Enzyme Based Formulated Feeds was consistent with the findings of Taye and Etefa (2020), which highlight the influence of feed enzymes and forage quality on nutrient digestibility and growth performance in hogs.

An essential component of nutrition and animal husbandry is the relationship between nutrients and animal growth. Optimizing production and maintaining animal welfare requires an understanding of how various nutrients support an animal's growth and development (Table 2).

The indigofera and flemingia legume plants was subject to laboratory analysis (Table 2) for crude fiber using the filter bag technique, AOCS approved procedures Ba6a-05 and the results marked a tangible decrease in the fiber content of different samples as revealed in Table 4. This proves that the fungus *T. harzianum* has the capability of degrading fiber in legume grasses. The crude fiber in T0 was brought to 5.50% lower than T1 with 11.73 and T2 with 17.96%.

The main trend illustrated throughout the experimental data is a sharp initial fall in the total fiber content and a gradual rate of degradation. This process of degradation was hastened by the presence of *T. harzianum* as enzymes or microbes that were involved in fiber degradation. This is supported by the study of Crucello (2015) which provides new perspectives regarding the use of this species in biomass degradation processes and was found that

T. harzianum secretes a number of biomass-degrading enzymes, including cellulases and hemicellulases.

A diet rich in fiber has the potential to enhance growth performance, preserve gut health or the beneficial bacteria in the digestive system and optimize digestive function (Jin *et al.*, 2022). The digestive tract to continue operating normally, fiber must be a part of the diet (Lindberg, 2014).

In this study, the LPEBFF contains high crude protein content but low crude fiber content. This is correlated with the study of Galassi *et al.* (2010) that pigs fed with high-fiber diets expelled more nitrogen from their faces. In comparison to normal diets and high-fiber diets, urinary nitrogen is lower in the low-protein diets. Lowering the amount of protein in the diet while increasing the amount of fiber decreases nitrogen excretion.

In the same nutrient results, LPEBFF contains high fiber which is important for the animal body to absorb calcium for skeletal development correlates to the study of Whisner *et al.* (2016) showed that a high-fiber diet, that is, 85%, evidently improves the body's ability to absorb calcium which may be important for maintaining bone health during a period of rapid bone growth. The overall trend observed in the experimental data shows an evident decline of the total crude fiber content, through a gradual decrease of fiber degradation rate in the subsequent treatment.

Table 3 shows the growth performance of hogs across different feeding groups. The initial weights show a decreasing trend from T0 to T2, with mean weights of 9.45 kg, 8.39 kg and 7.84 kg, respectively. Similarly, the final weights exhibit the same pattern, with T0 hogs achieving the highest mean weight of 60.32 kg, followed by T1 36.44 kg and T2 19.31 kg.

Table 1: Nutrient content evaluation (%).

Nutrients	T0 (100% CF)	T1 (50% CF, 50% LPEBFF)				T2 (100% LPEBFF)			
		S1	S2	S3	S4	S1	S2	S3	S4
Crude fiber	5.50	13.76	12.05	11.80	11.34	22.01	18.60	18.10	17.18
Crude protein	16.00	18.50	19.05	19.40	19.74	21.00	22.10	22.80	23.47
Crude fat	3.00	1.91	1.90	1.89	1.88	0.82	0.80	0.78	0.76
Calcium	0.80	1.65	1.62	1.60	1.55	2.50	2.43	2.40	2.29
Phosphorus	0.70	0.52	0.52	0.51	0.50	0.34	0.33	0.31	0.29

CF- Commercial feeds, S- Sample, T0-Treatment 0, T1- Treatment 1 and T2- Treatment 2, LPEBFF- Leguminous plants enzyme based formulated feeds.

Table 2: Nutrient comparative analysis of CF and LPEBFF.

Nutrients	T0 (100% CF)	T1 (50% CF and 50% LPEBFF)	T2 (100% LPEBFF)	CV
Crude fiber	5.50c	11.73b	17.96a	3.07
Crude protein	16.00c	19.40b	22.79a	1.77
Crude fat	3.00a	1.89b	0.78c	0.53
Calcium	0.80c	1.59b	2.37a	2.32
Phosphorous	0.70a	0.51b	0.31c	1.97

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- the second higher value, c- the lowest value. T0-Treatment 0, T1- Treatment 1 and T2- Treatment 2, LPEBFF- Leguminous plants enzyme based formulated feeds.

The overall mean weight indicates that T0 receiving 100% commercial feeds had the highest average weight gain at 50.87 kg. This outcome implies that hogs fed with 100% commercial feeds exhibit superior growth compared to those receiving LPEBFF in varying proportions. The observed trend aligns with the findings of Van Mierlo *et al.* (2021) emphasizing the importance of farm characteristics and compositions of commercial feeds on the environmental impact and high productivity of hog production.

A comprehensive breakdown of the cost of feeds, income, profit and return of investment associated with different treatments throughout the study (Table 4). The expenses per head include costs for feeds, labor and piglets. Notably, T0 shows the highest total expenses, amounting to 11,452.66, as compared to T1 8,956.33 and T2 6,463.33.

On the other hand, the sales of slaughtered hogs significantly contribute to the total income, with T0 gaining

the highest income of 11,275.00, followed by T1 amounting to 8,404.17 and T2 with 7,204.17. Interestingly, the profit, was positive for T2 with 740.84, suggesting a potential financial benefit. In contrast, both T0 (-177.66) and T1 (-552.16) show negative profits, indicating financial losses. The return on investment (ROI) metric further highlights the economic viability of T2. This resonates with studies emphasizing the economic benefits of innovative feed formulations and technologies in the livestock industry (Gatune, 2018).

Evaluation of the meat quality

The meat quality produced was evaluated in terms of the following: tenderness, color, flavor, appearance and fat thickness. The pork sensory evaluations were performed in the food technology laboratory room with 27 panelists who had determined the overview of the meat quality parameters that include tenderness, color, flavor and general acceptability, assessed in terms of description

Table 3: Growth performance (kg).

Indicators	T0	T1	T2	Mean
Initial weight	9.45	8.39	7.84	8.56
Final weight	60.32	36.44	19.31	38.69
Weight gain	50.87	28.05	11.47	30.13

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

Table 4: Average cost of feeds (PhP).

Particular	T0	T1	T2
Expenses (per head)			
Feeds	5,719.33	3,223.00	730.00
Labor	1,733.33	1,733.33	1,733.33
Piglet	4,000.00	4,000.00	4,000.00
Total expenses	11,452.66	8,956.33	6,463.33
Income (per head)	11,275.00	8,404.17	7,204.17
Total income	11,275.00	8,404.17	7,204.17
Profit	-177.66	-552.16	740.84

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

Table 5: Meat quality produced 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.

and acceptability (Table 5). Tenderness, a crucial aspect of meat quality, shows a slight fluctuation throughout treatments, with T1 presenting a peak mean tenderness score of 3.11.

The acceptability of tenderness, on the other hand, exhibits an increasing trend, reaching 5.78 in T2, signifying an improvement in the overall tenderness of the meat. Color description and acceptability follow a similar pattern, with scores gradually increasing across the treatments. Flavor parameters also demonstrate an upward trend, indicating a positive impact on the sensory characteristics of the meat. The general acceptability scores consistently rise from T0 to T2, culminating in a mean score of 5.96 in T2 signifying a favorable overall evaluation.

The observed improvements in meat quality align with findings from related studies. For instance, research on alternative feed sources for pigs by Renaudeau *et al.* (2022) emphasizes the potential impact of dietary components on meat quality attributes.

Appearance and fat thickness

The average meat thickness in T0 was higher compared to the meat of T1 and T2. Conversely, similar findings were revealed in terms of fat thickness of the pork in treatments 0, 1 and 2 respectively (Fig 1). The results of this study correlate with the study of Zmudzińska *et al.* (2020), which showed that the fattening hogs fed with legume plants had significantly reduced fatness compared to the control hogs. While on the fat thickness recorded from five measurements, significant differences were found among the animals that were fed with the soybean meal diet.

As reflected in Table 6, a comparison of the weight of hogs between 100% commercial feeds and LPEBFF with a p-value of <0.001 was obtained. The correlation is significant since the p-value is <0.05 significance level. So, the hypothesis that there is no significant difference among growth performance of hogs, is rejected.

A comparative analysis of the financial aspects between LPEBFF and CF for hog raising under different



Fig 1: Meat quality appearance.

Table 6: Comparisons of the weight of hogs.

Treatment		Mean difference	Sig. ^b	95% confidence interval for difference	
				Lower bound	Upper bound
0	1	12.472*	.000	9.358	15.586
	2	21.312*	.000	18.198	24.426
1	0	-12.472*	.000	-15.586	-9.358
	2	8.840*	.000	5.726	11.954
2	0	-21.312*	.000	-24.426	18.198
	1	-8.840*	.000	-11.954	-5.726

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

Table 7: Comparison of feed costs (PhP).

Indicator	T0	T1	T2
Expenses	11,452.66	8,956.33	6,463.33
Income	11,275.00	8,404.17	7,204.17
Profit	-177.66	-552.16	740.84
ROI	-1.55%	-6.17%	11.46%

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

treatments (Table 7). In Treatment 0 with 100% CF were used, the expenses per head exceeded the income resulted to a negative profit of -177.66 and a return on investment (ROI) of -1.55%. This suggests an unfavorable economic outcome, potentially indicating inefficiencies in the use of commercial feeds alone.

In Treatment 1, a mixture of 50% CF and 50% LPEBFF was employed. Due to higher expenses because of inclusion of commercial feeds, the income generated led to a more significant negative profit of -552.16, with an ROI of -6.17%.

Treatment 2, exclusively using LPEBFF, demonstrated a more favorable financial outcome. With lower feed expenses and higher income, there was a positive profit of 740.80, yielding an ROI of 11.46%. This indicates the economic viability of adopting LPEBFF, particularly when used exclusively. The finding aligns with studies emphasizing the economic benefits of incorporating alternative and sustainable feed sources in livestock farming as noted by Michalk *et al.* (2019).

CONCLUSION

The introduction of LPEBFF showed promising results in terms of meat quality, with improvements observed in tenderness, color, flavor and general acceptability.

The economic analysis, comparing LPEBFF with commercial feeds, emphasizes the favorable financial outcome associated with the exclusive use of LPEBFF, suggesting its potential to contribute positively to the financial sustainability of hog-raising operations. LPEBFF 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.

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Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

- Barroga, A.J. (2014). A dynamic Philippine swine industry: The key to meeting challenges and technological innovations. *Agricultural and Food Sciences*. doi: 10.56669/mfvj7445.
- Baruah, K.K., Khargharia, G., Deori, S., Kadirvel, G., Doley, S., Baruah, A. and Abedin, S.N. (2024). Effect of feeding sun dried banana pseudostem as a partial replacement of dietary maize on performance and production economics of crossbred grower pigs. *Indian Journal of Animal Research*. **58(4)**: 622-627. doi: 10.18805/IJAR.B-4975.
- Bollido, M.E., Villaluz, R.J.G. and Orale, R.L. (2022). Emerging supply chain of pork and the opportunities for small scale raisers in catbalogan city in the Philippines. *Sarhad Journal of Agriculture*. **38(4)**: 1370-1380.
- Crucello, A., Sforca, D.A., Horta, M.A.C., dos Santos, C.A., Viana, A.J.C., Beloti, L.L. and de Souza, A.P. (2015). Analysis of genomic regions of *Trichoderma harzianum* IOC-3844 related to biomass degradation. *PLoS one*. **10(4)**: e0122122.
- Galano, J.A. (2020). Economic Situation of Hog Grower Industry in Nueva Ecija: Problems and Prospects. *International Journal of Innovative Science and Research Technology*. **5(9)**: 1065-1069.
- Galassi, G., Colombini, S., Malagutti, L., Crovetto, G.M. and Rapetti, L. (2010). Effects of high fiber and low protein diets on performance, digestibility, nitrogen excretion and ammonia emission in the heavy pig. *Animal Feed Science and Technology*. **161(3-4)**: 140-148.
- Gatune, J. (2018). Upgrading Africa's Agricultural Value Chains- Catalyzing Business Model Innovations. *Latin American Report*. **34(1)**: 1-26.
- Gopalakrishnan, R. (2019). Advantages and nutritional value of organic food on human health. *International Journal of Trend in Scientific Research and Development*. **3(4)**: 242-245.
- Hurtado-Barroso, S., Tresserra-Rimbau, A., Vallverdú-Queralt, A. and Lamuela-Raventós, R.M. (2019). Organic food and the impact on human health. *Critical Reviews in Food Science and Nutrition*. **59(4)**: 704-714.
- Hussein, S., Xiaoying, Y., Farouk, M.H., Abdeen, A., Hussein, A. and Hailong, J. (2021). The role effects of dietary fiber on intestinal microbial composition and digestive physiological functions of pigs: A review. *Indian Journal of Animal Research*. **55(7)**: 737-743. doi: 10.18805/IJAR.B-1345.
- Jin, S., Wijerathne, C.U., Au-Yeung, K.K., Lei, H., Yang, C. and O, K. (2022). Effects of high-and low-fiber diets on intestinal oxidative stress in growing-finishing pigs. *Journal of Animal Science*. **100(11)**: skac306.
- Johnson, I.T. (2017). The cancer risk related to meat and meat products. *British Medical Bulletin*. **121(1)**: 73-81.
- Jeong, S.H., Kang, D., Lim, M.W., Kang, C.S. and Sung, H.J. (2010). Risk assessment of growth hormones and antimicrobial residues in meat. *Toxicological Research*. **26**: 301-313.
- Kambashi, B., Boudry, C., Picron, P. and Bindelle, J. (2014). Forage plants as an alternative feed resource for sustainable pig production in the tropics: A review. *Animal*. **8(8)**: 1298-1311.
- Lancheros, J.P., Espinosa, C.D., Lee, S.A., Oliveira, M.S. and Stein, H.H. (2022). Fiber in Swine Nutrition. Sustainable Swine Nutrition. pp 375-409.
- Lindberg, J.E. (2014). Fiber effects in nutrition and gut health in pigs. *Journal of Animal Science and Biotechnology*. **5(1)**: 1-7.
- Lippi, G., Mattiuzzi, C. and Cervellin, G. (2016). Meat consumption and cancer risk: A critical review of published meta-analyses. *Critical Reviews in Oncology/Hematology*. **97**: 1-14.
- Long, S., Liu, S., Wu, D., Mahfuz, S. and Piao, X. (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.
- Malsawmthangi, S., Kukde, R.J. and Samanta, A.K. (2016). Effect of diet containing sweet potato (*Ipomoea batatas*) meal on nutrient utilization and growth performance of indigenous growing pigs. *Indian Journal of Animal Research*. **50(5)**: 717-720. doi: 10.18805/ijar.7492.

- Michalk, D.L., Kemp, D.R., Badgery, W.B., Wu, J., Zhang, Y. and Thomassin, P.J. (2019). Sustainability and future food security-A global perspective for livestock production. *Land Degradation and Development*. **30(5)**: 561-573.
- 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 Raza, I. (2012). Scientific Evidences that Pig Meat (Pork) is Prohibited for Human Health. *Scientific Papers. Series D. Animal Science*. **55**: 281-286.
- Renaudeau, D., Jensen, S.K., Ambye-Jensen, M., Adler, S., Bani, P., Juncker, E. and Stødkilde, L. (2022). Nutritional values of forage-legume-based silages and protein concentrates for growing pigs. *Animal*. **16(7)**: 100-572.
- Saikia, P., Nag, A., Anurag, S., Chatterjee, S. and Khan, M.L. (2020). Tropical Legumes: Status, Distribution, Biology and Importance. In: *The Plant Family Fabaceae: Biology and Physiological Responses to Environmental Stresses*. Chapter: 2, Publisher: Springer Nature Singapore Pte Ltd. pp 27-41.
- Taye, D. and Etefa, M. (2020). Review on improving nutritive value of forage by applying exogenous enzymes. *International Journal of Veterinary Sciences and Animal Husbandry*. **5**: 72-79.
- Van Mierlo, K., Baert, L., Bracquené, E., De Tavernier, J. and Geeraerd, A. (2021). The influence of farm characteristics and feed compositions on the environmental impact of pig production in flanders: Productivity, energy use and protein choices are key. *Sustainability*. **13(21)**: 11623.
- Whisner, C.M., Martin, B.R., Nakatsu, C.H., Story, J.A., MacDonald-Clarke, C.J., McCabe, L.D. and Weaver, C.M. (2016). Soluble corn fiber increases calcium absorption associated with shifts in the gut microbiome: A randomized dose-response trial in free-living pubertal females. *The Journal of Nutrition*. **146(7)**: 1298-1306.
- Zmudzińska, A., Bigorowski, B., Banaszak, M., Roślewska, A., Adamski, M. and Hejdysz, M. (2020). The effect of a diet based on legume seeds and rapeseed meal on pig performance and meat quality. *Animals*. **10(6)**: 1084.