Research Article

Effects of Pineapple Leaf Waste (*Ananas comosus*) on the Productivity, Digestibility and Health Status of Indonesian Local Sheep: *In Vivo* Study

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Abstract | The small ruminant sector faces a challenge due to the rising cost of feed ingredients. Utilizing pineapple leaf agro-industrial waste offers a breakthrough in cost reduction. This study evaluates the impact of pineapple leaf waste on sheep (*Ovis aries*), focusing on production, digestibility, physiology, and blood chemistry. Twenty-four fat-tailed sheep underwent three treatments over two months: control (P0), 5% pineapple leaf inclusion (P1), and 10% inclusion (P2). Statistical analysis revealed significant improvements in feed consumption, ADG, feed conversion, and IOFC in P1. Digestibility parameters were highest in P1. Physiological parameters remained within normal ranges. Blood chemistry showed highly significant changes in HDL and triglyceride levels, indicating potential health risks at higher supplementation levels. Overall, pineapple leaf supplementation positively impacts productivity and digestibility, but caution is warranted at higher levels due to potential health risks.

Keywords | *Ananas comosus*, Health, Leaves, Performance, Sheep

Received | August 12, 2024; **Accepted** | November 13, 2025; **Published** | February 07, 2026
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Citation | Rokana E, Firmansyah MD, Budhi SR, Subasnia F, Fiani NIO, Supartini N, Anggrahini S, Sadarman, Mukmin A, Sigit M, Baihaqi ZA (2026). Effects of pineapple leaf waste (*Ananas comosus*) on the productivity, digestibility and health status of Indonesian local sheep: *In vivo* study. J. Anim. Health Prod. 14(1): 244-251.
DOI | https://dx.doi.org/10.17582/journal.jahp/2026/14.1.244.251
ISSN (Online) | 2308-2801

INTRODUCTION

The integration of natural feed resources in the livestock industry remains a dynamic frontier, evolving in tandem with the escalating global food demand and an intensified focus on animal welfare (Kumar *et al*., 2023). Among the array of potential feed constituents, pineapple leaves (*Ananas comosus*) have emerged as a captivating prospect due to their nutritional content, including 10.22% crude protein, 32.90% crude fiber, 6.37% ash, 5.74% crude fat, 44.77% BETN and abundance in bioactive compounds such as bromelain enzymes, tannins, phenolic compounds, and flavonoids (Dhar *et al*., 2023; Silfiyani *et al*., 2023). Baihaqi *et al*. (2020a, b, 2023), Lisnanti *et al*. (2023), Prayudi *et al.* (2023), Baihaqi *et al.* (2024), Prasetyo *et al.* (2024) and Sakti *et al.* (2024) stated that the active compounds in agro-industry waste provide a support system (animal health, methane degradation and support of animal production) for livestock. Frequently relegated as agricultural byproducts, this research will reveal the potential of pineapple leaves as a feed source that significantly contributes to enhancing livestock productivity, physiological equilibrium, and overall animal health.

The impact of feed provision extends beyond mere influences on livestock growth and productivity; it also intricately shapes animal health and physiological well-being (Neethirajan, 2023). Pineapple leaves, harboring a spectrum of nutrients including fiber, protein, vitamins, and bioactive elements like the bromelain enzyme, harbor the potential to impart positive influences on the performance of livestock (Varilla *et al.*, 2021; Kyawt *et al.*, 2020). Preliminary investigations underscore that the inclusion of pineapple leaves in livestock diets goes beyond the realm of productivity enhancement; it extends to the modulation of metabolic processes and fortification of the animals' immune resilience against diseases and environmental sustainability (Pavan *et al.*, 2012). Environmental balance needs to be addressed in the livestock sector as this issue contributes to global warming (Baihaqi *et al.*, 2022).

Nevertheless, notwithstanding the captivating preliminary findings, a profound comprehension of the operative mechanisms and the enduring repercussions of pineapple leaf utilization necessitates further exploration (Putriana *et al.*, 2020). This study aims to investigate the effects of administering pineapple leaves to livestock, focusing on productivity, physiological equilibrium, and overall health. The expected outcomes of this research aim to identify a potential alternative feed that is cost-effective due to its waste-based nature, while also having a positive impact on livestock productivity and confirming health status.

MATERIALS AND METHODS

Study period and location

The research took place between January 23, 2023, and March 19, 2023. *In vivo* studies were conducted on Ngampel Street, Tunge, Wates, Kediri Regency. Pineapple leaf waste is collected from the slopes of Mount Kelud, Kediri Regency. Hematology and blood chemistry analyses were performed at the Faculty of Medicine, Universitas Brawijaya, while nutritional assessments were carried out at the Department of Animal Nutrition and Feed Science, Faculty of Animal Husbandry, Universitas Gadjah Mada.

Research design

The materials utilized in this study comprised 24 fat-tailed female sheep aged approximately 8 to 10 months. The feed formulation involved a complete feed with various feed ingredients and the addition of pineapple leaves. The pineapple leaves used for this research were treated with chopper to reduce their size and to crush the spines on the pineapple leaves. After being chopped finely, the pineapple leaves are spread out in an open area for about half an hour to reduce their moisture content. An adaptation period of four weeks and the research employed an experimental design using a randomized complete block design (RCBD) with 3 treatments and 8 replications, resulting in a total of 24 units. Each experimental unit consisted of one sheep. The treatments administered for 2 months were as follows:

- P0: Formulation 1 without the addition of pineapple leaves
- P1: Formulation 2 + 5% pineapple leaves
- P2: Formulation 3 + 10% pineapple leaves

The nutritional content of the experimental rations can be found in Table 1.

Table 1: Nutrient content of rations.

Proximate analysis	Treatment		
	P0 (%)	P1 (%)	P2 (%)
Dry Matter	89.13	82.61	78.92
Ash	8.55	8.92	8.86
Crude Protein	15.34	15.71	15.29
Crude Fat	2.91	2.75	2.74
Crude Fiber	18.47	19.39	21.88

Research materials, including beer dregs and various feed ingredients, were procured from PT. Sadewa Animal Feed Tulungagung. The formulation of raw materials for the complete feed comprised copra, palm oil meal, corn gluten feed, white pollard, cassava cobs, soybean hulls, and Corn husk. The selection of 5% and 10% pineapple leaf substitution percentages was an experimental design choice by the team. The observational parameters encompassed consumption, feed digestibility, average daily gain (ADG), feed conversion, and income over feed cost (IOFC), following the methodology delineated by Suwignyo *et al.* (2017) and Lokapirnasari *et al.* (2024). Physiological and blood chemistry parameters were collected from each sheep and analyzed individually according to the research parameters. The physiological parameters taken in this study include respiratory rate, heart rate, and rectal temperature. Feces collection, conducted over the seven days preceding the study's conclusion, involved precise measurements, meticulous drying, and subsequent proximate analysis for dry matter, organic matter, and crude protein. Blood sampling was conducted at the end of the treatment and blood chemistry analyses adhered to the established methodology outlined by Baihaqi *et al.* (2020) and Rokana *et al.* (2024).

Table 2: Sheep performance data.

	Treatments		
	P0	**P1**	**P2**
Feed consumtion (DM) (kg/head/day)	0.891±0.0001[c]	0.826±0.00004[b]	0.789±0.00005[a]
ADG (gr/head/day)	91.22±3.98[b]	105.31±6.42[c]	86.03±1.67[a]
Feed convertion	9.781±0.42[c]	7.854±0.47[a]	9.180±0.18[b]
Feed Efficiency (%)	10.24±0.44[a]	12.75±0.78[a]	10.90±0.21[a]
IOFC (IDR/head)	92.937.25 ± 5.385.97[b]	110.436.38 ± 6.566.42[c]	65.705.50 ± 8.312.23[a]

Note: Different notations in the same column indicate a significantly different effect (P < 0.05) between treatments. ADG: Average Daily Gain; IOFC: Income Over Feed Cost.

Data analysis

The collected data will be analyzed using ANOVA. If the results show a significant difference (P<0.05) or a highly significant difference (P<0.01), a post hoc test, specifically the Least Significant Different (LSD) test, will be conducted for further comparisons.

RESULT

The research findings related to performance values are presented in Table 2.

The analysis of variance results indicates that the addition of pineapple leaf supplementation significantly produces markedly different treatment effects on feed consumption (P<0.01). The inclusion of 5% pineapple leaf in the diet for Treatment P1 resulted in higher average feed consumption compared to Treatments P0 and P2, with mean values for P0, P1, and P2 being 0.891±0.0001 kg/head/day[c], 0.826±0.00004 kg/head/day[b], and 0.789±0.00005 kg/head/day[a], respectively. The analysis of variance results shows that the average daily weight gain (Table 2) with pineaple leaf supplementation yields significantly different treatment effects (P<0.01). The addition of 5% pineapple leaf in Treatment P1 resulted in a higher average daily weight gain compared to Treatments P0 and P2, with mean values for Treatment P0 ranging around 91.22 g/head/day, Treatment P1 around 105.31 g/head/day, and Treatment P2 around 86.03 g/head/day.

The analysis of variance results demonstrates that feed conversion with the addition of pineapple leaf in different-level sheep feed formulations undergoes significantly different effects (P<0.01) on feed conversion. The results of the feed efficiency analysis show that the addition of pineapple leaf to female sheep does not significantly differ (P>0.05) in terms of feed efficiency. The analysis of variance for Income Over Feed Cost (IOFC) shows that the addition of pineapple leaf in different-level sheep feed formulations undergoes significantly different effects (P<0.01) on IOFC. The average values for Income Over Feed Cost (IOFC) for Treatments P0, P1, and P2 are Rp95.937.25; Rp110.436.38; and Rp65.705.50, respectively.

The research results related to nutrient digestibility values are presented in Table 3.

Table 3: Nutrient digestibility values.

	Treatments		
	P0	**P1**	**P2**
IVDMD (%)	68.65±2.44[a]	75.63±2.23[b]	66.46±3.34[a]
IVOMD (%)	70.78±2.35[a]	76.73±2.10[b]	68.30±3.13[a]
IVCPD (%)	74.98± 3.73[a]	78.74± 3.44[b]	72.46± 4.32[a]

Note: Different notations in the same column indicate significantly different effects (P < 0.05) between treatments. IVDMD: *In Vivo* Dry Matter Digestibility; IVOMD: *In Vivo* Organic Matter Digestibility; IVCPD: *In Vivo* Crude Protein Digestibility.

The analysis of variance for Nutrient Digestibility (IVDMD) indicates that the nutrient digestibility of feed with pineapple leaf supplementation yields significantly different treatment effects (P<0.05). The addition of 5% pineapple leaf in Treatment P1 resulted in higher averages compared to Treatments P0 and P2, with mean values for P0, P1, and P2 being 68.65±2.44%[a], 75.63±2.23%[b], and 66.46±3.34%[a], respectively. The analysis of variance results show that the addition of pineapple leaf supplementation in female sheep significantly influences (P<0.05) organic matter digestibility (IVOMD). The mean values for organic matter digestibility for Treatments P0, P1, and P2 are 70.78±2.35%[a], 76.73±2.10%[b], and 68.30±3.13%[a], respectively. The analysis of variance results indicate that the addition of pineapple leaf supplementation in different-level sheep feed formulations undergoes significantly different effects (P<0.05) on crude protein digestibility (IVCPD). The mean values for P0, P1, and P2 are 74.98±3.73%[a], 78.74±3.44%[b], and 72.46±4.32%[a], respectively.

Research findings related to physiological status values are presented in Table 4.

The results in the average values in Table 4 indicate that the treatment with 5% pineapple leaf supplementation (P1) resulted in a respiratory rate of 40.48 breaths/minute, and the treatment with 10% pineapple leaf supplementation (P2) had a respiratory rate of 40.68 breaths/minute. An analysis of variance was conducted, and the result ($P>0.05$) suggests no significant effect, and the results obtained under normal conditions. The results in the average pulse frequency in Table 4 state that the treatment with 5% pineapple leaf supplementation (P1) had a pulse frequency of 98.87 beats/minute, and the treatment with 10% pineapple leaf supplementation (P2) had a pulse frequency of 100.66 beats/minute. An analysis of variance was conducted, and the result ($P>0.05$) suggests no significant effect, and the results obtained under normal conditions. The results in the average values in Table 4 state that the rectal temperature with 5% pineapple leaf supplementation treatment (P1) was 38.86°C, and the treatment with 10% pineapple leaf supplementation (P2) was 38.73°C. An analysis of variance was conducted, and the result ($P>0.05$) suggests no significant effect.

Table 4: Physiological status values of sheep.

	Treatments		
	P0	**P1**	**P2**
Respiratory rate (breaths/minute)	40.72±1.12	40.48±1.47	40.68±1.92
Heart rate (beats/minute)	97.08±6.04	98.87±4.60	100.66±8.75
Rectal temperature (°C)	38.63±0.49	38.86±0.21	38.73±0.59

Note: No significant differences.

The influence of adding pineapple leaf waste supplement on the blood biochemical profile of fat-tailed female sheep is presented in Table 5.

Table 5: Chemical blood values of sheep.

	Treatments		
	P0	**P1**	**P2**
LDL (mg/dl)	23.63±3.8	26.38 ± 3.29	25.75±6.36
HDL (mg/dl)	30.38±2.97[a]	38.25±6.80[b]	44.38±6.95[c]
Triglyceride (mg/dl)	29.13±5.11[a]	26.13±5.49[a]	38.63±4.78[b]

Note: The same notation in the same column indicates a non-significant effect ($P>0.05$) between treatments. LDL: Low Density Lipoprotein; HDL: High Density Lipoprotein.

The calculation results in Table 5 for LDL levels with the addition of 5% pineapple leaf waste supplementation (P1) at 26.38±3.29 mg/dl and 10% (P2) at 25.75±6.36 mg/dl were followed by an analysis of variance, and the result showed no significant effect ($P>0.05$). The calculation results in Table 5 for HDL levels with 5% pineapple leaf supplementation (P1) at 38.25±6.80 mg/dl and 10% (P2) at 44.38±6.95 mg/dl were followed by an analysis of variance, and the result showed a highly significant effect ($P<0.01$). The calculation results in Table 5 for triglyceride levels with 5% pineapple leaf supplementation (P1) at 26.13±5.49 mg/dl and 10% (P2) at 38.63±4.78 mg/dl were followed by an analysis of variance, and the result showed a highly significant effect ($P<0.01$).

DISCUSSION

Feed consumption is closely tied to the energy requirements of animals, contributing to variations in feed intake across different individuals. The decrease in feed consumption in P1 and P2 compared to P0 is influenced by the form of feed substrate and palatability, considering that in this research, there is an addition of pineapple leaves which have spines, although they have received chopped treatment. Llonch *et al*. (2018) stated that measurements of feed consumption can be influenced by individual differences among animals, feed palatability, and selective grazing tendencies. Khatri and Huff-Lonergan (2025) stated that the value of feed consumption can be seen from the nutrient content and is influenced by feed palatability. Wang *et al*. (2022) stated that the positive supplementation of *L. virgaurea*, which contains secondary metabolites such as EO, flavonoids, alkaloids, steroids, and saponins, can affect feed intake in sheep. High levels of *L. virgaurea* supplementation can decrease the palatability of the feed, thereby reducing nutrient intake. The decrease in feed intake at the highest level of pineapple leaf supplementation is similar to the results of the above-mentioned study, likely due to the active compounds contained in the plant.

The research findings on average daily gain are supported by Roba *et al*. (2022), who stated that the the weight gain of ruminant livestock is notably affected by both the quality and quantity of their feed, suggesting that the evaluation of weight gain is directly proportional to the consumed ration. The ADG in this study's P1 showed an increase, while P2 exhibited a decrease compared to the control, consistent with the feed digestibility conditions in the research, besides the effects of active compounds in pineapple leaves influencing this condition and feed consumption.

The average values for feed conversion in this study range between 7.85 and 9.78. This is supported by Roba *et al*. (2022), who mentioned that feed conversion, particularly in ruminant livestock, is impacted by feed quality, weight gain, and digestibility values. Optimal feed quality contributes to enhanced animal growth and improved feed conversion.

Further tests show that the average values of feed efficiency for Treatment P0 result in approximately 10.90%, Treatment P1 yields an average of 12.75%, and Treatment P2 produces an average of 10.24%. Feed utilization efficiency is influenced by several factors, including the animal's ability to digest feed ingredients, the adequacy of nutrients for basic life functions, growth and bodily functions, and the type of feed used (Wang *et al.*, 2025).

The lowest average Income Over Feed Cost (IOFC) is found in Treatment P2, while the highest average is in Treatment P1. The selling price of female fat-tailed sheep during the study is Rp57.000 per kg after the rearing period. The prices of feed used in this study for each treatment are as follows: feed P0 at Rp3.605 per kg, feed P1 at Rp3.426 per kg, and feed P2 at Rp3.490 per kg. These results are consistent with those presented by Muyasaroh *et al.* (2015), indicating that the Cost of Feed per Body Weight Gain during fattening, feed consumption, and feed prices are influential factors in IOFC calculations. Emphasized by the research of Rab *et al.* (2016), it is stated that optimal profits in fattening businesses are influenced by low feed costs, followed by good growth and feed efficiency results.

A higher percentage of dry matter digestibility in a feed ingredient suggests a higher quality of that feed ingredient. Supported by Mertens and Grant (2020) statement that high dry matter digestibility suggests a significant quantity of digestible nutrients. The greater the digestibility value of a feed component, the superior the quality of the feed. The administration of active compounds at the right concentration has a positive effect on sheep digestion. Research using active compounds does pose challenges because each plant contains different active compounds. Saleem *et al.* (2006) stated that The administration of (Cassia fistula, Schinus molle, Chorisia speciosa, and Eucalyptus camaldulensis), which contain active compounds, positively affects the improvement of digestion in sheep. Wang *et al.* (2022) added that the appropriate addition of *L. virgaurea* to the diet of Tibetan sheep improves digestibility. However, excessive amounts can have toxicological effects. The significant decrease in P2 could be attributed to the active compounds present in pineapple leaf waste. Marhaeniyanto *et al.* (2018) stated that concentrate with the addition of legumes containing active tannin compounds had an impact on reducing feed digestibility.

Organic matter digestibility is related to dry matter digestibility according to Surono *et al.* (2025). This statement is reinforced by Suwignyo *et al.* (2021), stating that low digestibility of dry matter leads to low digestibility of organic matter or vice versa, as a portion of dry matter comprises organic matter. The average IVCPD values in this study are supported by Reis *et al.* (2023) stated that the inefficiency in utilizing consumed crude protein feed by animals is linked to the high solubility of crude protein in the rumen. Conversely, proteins with lower solubility have the potential to enter the post-ruminal digestive tract, enabling efficient digestion, estimation, and absorption of the protein.

Pulse frequency on this study can be influenced by livestock metabolism. Nie *et al.* (2020) mentioned that the pulse frequency is closely linked to the metabolic rate of livestock. Factors affecting livestock pulse frequency include gender, muscle activity, environmental temperature, and feed consumption rate. The increase in respiratory frequency in livestock is carried out to prevent a continuous rise in body temperature through evaporation. A decrease in respiratory frequency also affects different metabolic rates in the categorization of body weight in each sheep (Neethirajan, 2020). Emphasized by the statement of Volkoff *et al.* (2020), high-quality feed has a positive impact on animal growth, maintaining a stable (normal) body temperature. Insufficient feed, on the other hand, may result in the animal's body temperature exceeding the normal range.

This finding on this study differs from Prayitno and Heni (2021), who stated that the blood lipid profile of sheep with LDL levels ranged from 36.33 to 43.94 mg/dl. Belhaj *et al.* (2021) stated that the average LDL levels in fat-tailed female sheep with normal levels ranged from 15.39 to 39.5 mg/dl, reducing the risk of atherosclerosis by preventing plaque deposition in the arteries due to the accumulation of metabolic waste in the arteries. This result on this study was supported by Cho (2022), where HDL concentrations varied between 22.25-46.25 mg/dl, and increasing HDL levels play a crucial role in binding excess cholesterol and transporting it with the bloodstream towards the liver, reducing the risk of atherosclerosis. Research on blood chemistry should be conducted because projects involving the utilization of active compounds from plants require clinical confirmation, similar to a special mission aimed at eradicating cases of worm infections (Baihaqi *et al.*, 2019). The levels obtained in this study are much higher and differ from Mugabe *et al.* (2017), who reported triglyceride concentrations ranging from 13.87 to 25.14 mg/dl. Sarmin *et al.* (2021) added that the normal triglyceride levels in sheep range from 5.41 to 13.35 mg/dL. This study aligns with the findings of Widyawati *et al.* (2023), where sheep fed concentrate with the addition of linseed flour (tannin protection) resulted in higher triglyceride levels compared to the normal range. Higher triglyceride levels can lead to hypertriglyceridemia in sheep, adversely affecting the arteries. The likelihood is that the changes in parameter concentration are related to decreased feed intake.

CONCLUSION

The utilization of pineapple leaf waste in this in vivo study yielded positive effects on production performance, with treatment P1 showing the most significant improvement in ADG and IOFC. This is likely due to the active compounds in pineapple leaves. Digestibility of dry matter, organic matter, and crude protein showed notable changes. Physiological status remained normal, with LDL cholesterol levels decreasing and HDL and triglycerides increasing. However, excessive supplementation may pose health risks to sheep, as indicated by blood chemistry parameters. Further studies are needed to find the optimal dosage that maximizes benefits without health risks. Research should also explore the mechanisms behind pineapple leaf compounds' effects and test their use on other livestock and in different farming conditions. Practically, farmers can use pineapple leaf waste as a feed supplement, ensuring proper dosing to avoid health risks.

ACKNOWLEDGEMENT

This study was supported by the Program Kerjasama Penelitian UNISKA–BRIN Tahun 2023, with grant number 010/040.1.6/HK.01.03/VIII/2023.

NOVELTY STATEMENT

This study pioneers the optimal utilization of pineapple leaf agro-waste as a cost-effective feed supplement for fat-tailed sheep, demonstrating that 5% inclusion significantly enhances feed intake, average daily gain (ADG), feed efficiency, income over feed cost (IOFC), and nutrient digestibility while maintaining physiological homeostasis-unlike higher 10% levels that elevate triglycerides despite boosting HDL. Unlike prior research limited to in vitro assessments or non-ruminant models, our in vivo trial

AUTHOR'S CONTRIBUTION

ER, MDF, SRB, FS, NIOF, NS, SA, S, AM, MS, ZAB: Designed the study and collected samples and performed examinations. All authors have drafted and revised the manuscript. All authors have read, reviewed, and approved the final manuscript.

Ethical approval

The research obtained approval from the Animal Care and Use Committee at Universitas Brawijaya, Indonesia under the reference number: 208 – KEP – UB – 2023.

Generative AI and AI-assisted technology statement

AI tools were employed solely for grammar corrections and sentence refinements. The authors confirm that all scientific content, data analyses, interpretations, and conclusions represent their original work exclusively.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Ajayi AM, Coker AI, Oyebanjo OT, Adebanjo IM, Ademowo OG (2022). *Ananas comosus* (L) *Merrill* (pineapple) fruit peel extract demonstrates antimalarial, anti-nociceptive and anti-inflammatory activities in experimental models. J. Ethnopharmacol., 282. https://doi.org/10.1016/j.jep.2021.114576

Baihaqi ZA, Widiyono I, Nurcahyo W (2019). Prevalence of gastrointestinal worms in Wonosobo and thin tailed sheep on the slop of mount sumbing, Central Java, Indonesia. Vet. World, 12(11): 1866-1871. https://doi.org/10.14202/vetworld.2019.1866-1871

Baihaqi ZA, Widiyono I, Nurcahyo W (2020a). Prevalence naturally infected GI parasites and complete blood count condition on Wonosobo sheep at Wonosobo District, Central Java, Indonesia. Biodiversitas, 21(7): 3057-3061. https://doi.org/10.13057/biodiv/d210724

Baihaqi ZA, Widiyono I, Nurcahyo W (2020b). Potential of *Carica pubescens* fruit peel as an alternative method to control *Haemonchus contortus* in small ruminant. Livest. Res. Rural Dev. J., 32(7).

Baihaqi ZA, Widiyono I, Nurcahyo W (2020c). *In vitro* anthelmintic activity of aqueous and ethanolextract of *Paraserianthes falcataria* bark waste against *Haemonchus contortus* obtained from a local slaughter house in Indonesia. Vet. World, 13(8): 1549-1554. https://doi.org/10.14202/vetworld.2020.1549-1554

Baihaqi ZA, Widiyono I, Angeles AA, Suwignyo B, Nurcahyo W (2023). Anthelmintic activity of *Carica pubescens* aqueous seed extract and its effects on rumen fermentation and methane reduction in Indonesian thin-tailed sheep: An *in vitro* study. Vet. World, 16(7): 1421-1428. https://doi.org/10.14202/vetworld.2023.1421-1428

Baihaqi ZA, Widiyono I, Suwignyo B, Angeles AA (2022). Alternative strategies of plant metabolite secondary "Tannin" for methane emission reduction on ruminant livestock: A reviews of the last 5 years literature. Adv. Anim. Vet. Sci., 10(3): 599-606. https://doi.org/10.17582/journal.aavs/2022/10.3.599.606

Baihaqi ZA, Anggrahini S, Wulandari, Sakti AA, Ibrahim A, Putri EM (2024). Anthelmintic potential of Swietenia mahagoni seed waste against Haemonchus contortus in Indonesian small ruminant. IOP Conf. Ser.: Earth Environ. Sci., 1417: 012045. https://doi.org/10.1088/1755-1315/1417/1/012045

Belhaj K, Mansouri F, Benmoumen A, Sindic M, Fauconnier ML, Boukharta M, Serghini CH, Elamrani A (2020). Fatty acids, health lipid indices, and cholesterol content of sheep meat of three breeds from Moroccan pastures. Arch. Anim. Breed., 63(2): 471-482. https://doi.org/10.5194/aab-63-471-2020

Cho KH (2022). The current status of research on high-density lipoproteins (HDL): A paradigm shift from HDL quantity to HDL quality and HDL functionality. Int. J. Mol. Sci., 23(7): 3967. https://doi.org/10.3390/ijms23073967

Dhar P, Nickhil C, Pandiselvam R and Deca SC (2023). Pineapple waste-based-biorefinery for sustainable generation of value-added products. Biomass Conv. Biorefnery, https://doi.org/10.1007/s13399-023-04801-w

Khatri Y and Huff-Lonergan E (2025). Eating quality of ribeye steaks from young bulls and steers is comparable: A study examining the effect of sex, frame size, and feed time on palatability attributes. Food Sci. Nutr., 13(7): e70359. https://doi.org/10.1002/fsn3.70359

Kumar P, Abubakar AA, Verma AK, Umaraw P, Ahmed MA, Mehta N, Hayat MN, Kaka U, Sazili AQ (2023). New insights in improving sustainability in meat production: opportunities and challenges. Crit. Rev. Food Sci. Nutr., 63(33): 11830-11858. https://doi.org/10.1080/10408398.2022.2096562

Kyawt YY, Win KS, Mu KS, Aung A, Aung M (2020). Feeding pineapple waste silage as roughage source improved the nutrient intakes, energy status and growth performances of growing Myanmar local cattle. J. Adv. Vet. Anim. Res., 7(3): 436-441. https://doi.org/10.5455/javar.2020.g439

Lisnanti EF, Lokapirnasari WP, Hestianah EP, Al Arif MA, Baihaqi ZA (2023). The effectiveness of giving marsh fleabane (*Pluchea indica* L.) Water extract on broiler hematology and blood glucose. Adv. Anim. Vet. Sci., 11(8): 1348-1356. https://doi.org/10.17582/journal.aavs/2023/11.8.1348.1356

Llonch P, Mainau E, Ipharraguerre IR, Bargo F, Tedó G, Blanch M, Manteca X (2018). Chicken or the egg: The Reciprocal association between feeding behavior and animal welfare and their impact on productivity in dairy cows. Front. Vet. Sci., 5: 305. https://doi.org/10.3389/fvets.2018.00305

Lokapirnasari WP, Al-Arif MA, Hidayatik N, Safiranisa A, Arumdani DF, Zahirah AI, Yulianto AB, Lamid M, Marbun TD, Lisnanti EF, Baihaqi ZA, Khairullah AR, Kurniawan SC, Pelawi EBS, Hasib A (2024). Effect of probiotics and acidifiers on feed intake, egg mass, production performance, and egg yolk chemical composition in late-laying quails. Vet. World, 17(2): 462–469. https://doi.org/10.14202/vetworld.2024.462-469

Marhaeniyanto E, Susanti S (2018). Ruminal fermentability *in vitro* supplementation *Gliricidia sepium*, *Moringa oleifera* Lamk, *Ceiba pentandra* and *Paraserianthes falcataria* leaf meal in green concentrate. J. Ilmu-Ilmu Petern., 28(3): 213-223. https://doi.org/10.21776/ub.jiip.2018.028.03.04

Mertens DR, Grant RJ (2020). Digestibility and Intake. Forages Chapter 34. https://doi.org/10.1002/9781119436669.ch34

Mugabe LC, Bagaldo AR, Barbosa LP, Araújo FL, Oliveira BYS, Silva RV MM, Oliveira RL, Pinheiro EEG (2017). Biochemical and seminal parameters of lambs fed palm kernel cake under grazing system. Rev. Brasil. Zoot., 46(8): 670-677. https://doi.org/10.1590/s1806-92902017000800007

Muyasaroh S, Budisatria IGS, Kustantinah (2015). Income over feed cost penggemukan sapi oleh kelompok Sarjana Membangun Desa (SMD) di Kabupaten Bantul dan Sleman. Buletin Peternakan, 39(3): 205–211. https://doi.org/10.21059/buletinpeternak.v39i3.7989

Neethirajan S (2020). Transforming the adaptation physiology of farm animals through sensors. Animals, 10(9): 1512. https://doi.org/10.3390/ani10091512

Neethirajan S (2023). Artificial intelligence and sensor innovations: Enhancing livestock welfare with a human-centric approach. Human-centric intelligent systems. https://doi.org/10.1007/s44230-023-00050-2

Nie L, Berckmans D, Wang C, Li B (2020). Is continuous heart rate monitoring of livestock a dream or is it realistic? A review. Sensors, 20(8): 2291. https://doi.org/10.3390/s20082291

Pavan R, Jain S, Shraddha, Kumar A (2012). Properties and therapeutic application of bromelain: A review. Biotechnol. Res. Int., https://doi.org/10.1155/2012/976203

Prasetyo EN, Rokana E, Baihaqi ZA, Samudi S (2024). Anthelmintic effects of Podang mango (*Mangifera indica*) fruit peel waste extract through *in vivo* application on Indonesian Etawa goat production and health. Vet. World, 17(6): 1291-1298. https://doi.org/10.14202/vetworld.2024.1291-1298

Prayudi SKA, Effendi MH, Lukiswanto BS, Az Zah-Ra RL, Benjamin MI, Kurniawan SC, Khairullah AR, Silaen OSM, Lisnanti EF, Baihaqi ZA, Widodo A, Riwu KHP (2023). Detection of genes on *Escherichia coli* producing extended spectrum β-lactamase isolated from the small intestine of ducks in traditional markets Surabaya city, Indonesia. J. Adv. Vet. Res., 13(8): 1600-1608.

Prayitno RS, Heni N (2021). Effect of feeding shallot leaf waste (*Allium ascalonicum* L.) as an alternative forage on blood lipid profile of sheep. J. Peternakan, 18: 19–24.

Putriana L, Bachruddin Z, Hanim C, Kurniawati A, Yusiati LM, Widayati O (2020). The effect of bromelain from pineapple (*Ananas comosus*) on increasing protein digestibility of milk replacer for lamb. IOP Conf. Ser. Earth Environ. Sci., 478: 012030. https://doi.org/10.1088/1755-1315/478/1/012030

Rab SA, Priyanto R, Fuah AM and Wiryawan IKG, 2016. Carrying capacity and efficiency production of Madura cattle through the utilization of soybean waste. Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan 4(3): 340–344. https://doi.org/10.29244/jipthp.4.3.340-344

Reis IA, Souza MG, Granja-Salcedo YT, Carvalho IPC, Porcionato MAF, Prados LF, Siqueira GR, De Resende FD (2023). Effect of post-ruminal urea supply on growth performance of grazing nellore young bulls at dry season. Animals, 13(2): 207. https://doi.org/10.3390/ani13020207

Roba RB, Letta MU, Aychiluhim TN, Minneeneh GA (2022). Intake, digestibility, growth performance and blood profile of rams fed sugarcane bagasse or rice husk treated with Trichoderma viride and effective microorganisms. Heliyon, 8(12). https://doi.org/10.1016/j.heliyon.2022.e11958

Rokana E, Fatimah IR, Dianingtyas BD, Hasanah N, Wulandari, Baihaqi ZA (2024). Impact of various fiber sources in ration formulas on feedlot performance of sheep in Indonesia. J. Anim. Health Prod., 12(3): 325-330. https://doi.org/10.17582/journal.jahp/2024/12.3.325.330

Sakti AA, Baihaqi ZA, Suwignyo B, Sofyan A, Herdian H, Kustantinah (2024). Anthelmintic activity of red macroalgae *Acrocystis* sp. and *Acanthophora* sp. etanolic extract against haemonchus contortus in sheep *in vitro*. IOP Conf. Ser.: Earth Environ. Sci., 1360: 012004. https://doi.org/10.1088/1755-1315/1360/1/012004

Salem AZM, Salem MZM, El-Adawy EE, Robinson PH (2006). Nutritive evaluations of some browse tree foliages during the dry season: Secondary compounds, feed intake and *in vivo* digestibility in sheep and goats, Anim. Feed Sci. Technol., 127(3–4): 251-267. https://doi.org/10.1016/j.anifeedsci.2005.09.005

Sarmin S, Winarsih S, Hana A, Astuti P, Airin CM (2021). Parameters of blood biochemistry in different physiological status of fat-tailed sheep. AIP Conf. Proc., 2353(1): 030070. https://doi.org/10.1063/5.0052634

Silfiyani W, Muhtarudin M, Fathul F, Erwanto E (2023). Effect long fermentation of pineapple leaves and *Aspergillus niger* of crude protein digestibility and ether extract digestibility *in vitro*. J. Riset Inovas. Petern., 7(4): 514-522. https://doi.org/10.23960/jrip.2023.7.4.514-522

Surono S, Sutrisno S, Surahmanto S (2025). Fermentability and total digestible nutrients of *Pennisetum purpureum* cv. Mott supplemented with buffalo rumen content as probiotic and various levels of readily available carbohydrate in Bali bull sheep in vitro. J. Adv. Vet. Res., 15(6): 873–877.

Suwignyo B, Baihaqi ZA, Utomo R, Sarmin, Widiyono I (2017). Effects of different feed restrictions on kacang goats. Pak. J. Nutr., 16: 236-241. https://doi.org/10.3923/pjn.2017.236.241

Suwignyo B, Rini EA, Fadli MK, Ariyadi B (2021). Effects of alfalfa (*Medicago sativa* L.) supplementation in the diet on the growth, small intestinal histomorphology, and digestibility of hybrid ducks. Vet. World, 14(10): 2719-2726. https://doi.org/10.14202/vetworld.2021.2719-2726.

Varilla C, Marcone M, Paiva L, Baptista J (2021). Bromelain, a group of pineapple proteolytic complex enzymes (*Ananas comosus*) and their possible therapeutic and clinical effects. A summary. Foods. https://doi.org/10.3390/foods10102249

Volkoff H, Rønnestad I (2020). Effects of temperature on feeding and digestive processes in fish. Temperature, 7(4): 307-320. https://doi.org/10.1080/23328940.2020.1765950

Wang Y, Sun Y, Liu Y, Wang Z, Chang S, Qian Y, Chu J, Hou F (2022). Ecological thresholds of toxic plants for sheep production and ecosystem multifunctionality and their trade-off in an alpine meadow. J. Environ. Manage., 323. https://doi.org/10.1016/j.jenvman.2022.116167

Wang J, Wu Y, Zhou T, Feng Y, Li LA (2025). Common factors and nutrients affecting intestinal villus height: A review. Anim. Biosci., 38(8): 1557–1569. https://doi.org/10.5713/ab.25.0002

Widyawati SD, Hanifa A, Hadi RF, Sudiyono, Handayanta E, Nuraini DM (2023). Profil kimia darah domba ekor gemuk setelah pemberian linseed dengan berbagai karakteristik fisik dalam complete feed. J. Livest. Anim. Health, 6(1): 15–20. https://doi.org/10.32530/jlah.v6i1.6