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Effect of Gliricidia, *Moringa and Leuceana* Leaves Meal on Growth Performance, Carcass Characteristics, Blood Indices and Meat Quality

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Abstract

Objective: This study investigated the effects of incorporating Gliricidia, Leucaena, and Moringa-based leaf meal supplements on rabbit production and meat quality. Driven by rising animal feed costs and disruptions caused by the COVID-19 pandemic, the research sought to identify affordable, nutritionally efficient alternative feed sources for livestock to ensure sustainable rabbit production.

Method: The research utilised 48 rabbits, divided into four groups, and fed different experimental diets for a specified period. The study employed descriptive statistics and Analysis of Variance (ANOVA) at $\alpha = 0.05$ to assess a comprehensive range of parameters, including growth performance, carcass characteristics, organ weights, haematological and serum biochemical indices, and various meat quality attributes.

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Results: Haematological analysis revealed that the 50% Moringa-based diet significantly improved growth performance, as evidenced by higher fasted and carcass weights, and enhanced haematological parameters, including packed cell volume and haemoglobin concentration. While the Gliricidia-based diet yielded higher weights for hind and forelimb cuts, the Moringa-based diet increased back weight, abdominal fat deposition, and improved digestive health via increased cecum weight. Additionally, the Moringa diet positively influenced cholesterol and HDL levels and demonstrated superior meat quality attributes, specifically lower cooking loss and higher water-holding capacity, although the control diet exhibited higher oxidative rancidity.

Conclusion: The study demonstrates that incorporating Moringa-based leaf meal into rabbit diets significantly improves growth performance, blood parameters, and meat quality. These findings suggest that Moringa is a viable, cost-effective alternative to traditional feeds, with potential to improve cardiovascular health indices and meat juiciness. Future research is needed to better understand lipid oxidation in leaf meal-based diets and to refine rabbit nutritional strategies further.

Keywords: Gliricidia-based diet, moringa-based diet, leuceana-based diet, growth performance, haematology, weaned rabbit

Introduction

Sustainable livestock production and the utilisation of natural feed ingredients have become essential priorities in the modern agricultural landscape. With a growing interest in eco-friendly and cost-effective alternatives, the use of plant-based feed supplements has garnered significant attention. Gliricidia, Moringa, and Leucaena leaves are among the most widely recognised and abundant plant resources with potential nutritional benefits for livestock (Aregheore, 2002; Makkar & Becker, 1996; Sánchez-Muñoz et al., 2021). In recent years, research has increasingly focused on the effects of incorporating these leaves into animal diets to enhance growth performance, carcass characteristics, blood indices, and meat quality (Sawal et al., 2018; Singh et al., 2020; Utrera et al., 2019). Gliricidia sepium, Moringa oleifera, and Leucaena leucocephala are valuable multipurpose tree species known for their high protein, fibre, minerals, and vitamins content (Makkar & Becker, 1996; Odero-Waitituh & Kingori, 2021). Traditionally, these leaves have been used as fodder for ruminants and other livestock due to their nutritional richness. Moreover, their leaves contain bioactive compounds, such as phenolics, flavonoids, and alkaloids, which may improve animal health and performance (Figueira et al., 2020; Rajalakshmi et al., 2019; Sawal et al., 2018).

This study aims to investigate the effect of Gliricidia, Moringa, and Leucaena leaf meal on various aspects of livestock production. Specifically, it seeks to evaluate the impact of these plant-based feed supplements on the growth performance of animals, carcass characteristics, blood indices related to health and immunity, and meat quality attributes (Aye et al., 2019; Fernández-Martínez et al., 2020; Utrera et al., 2019). Understanding the potential benefits of incorporating Gliricidia, Moringa, and Leucaena leaf meal into livestock diets holds significant promise for sustainable animal production systems. Such findings may support a shift toward eco-friendly, resource-efficient agriculture, thereby reducing reliance on costly conventional feed ingredients.

Additionally, this research may elucidate the nutritional value of these leaves and their bioactive compounds, offering insights for animal nutritionists, veterinarians, and livestock producers.

In the context of global challenges such as environmental degradation, climate change, and food security, exploring the use of abundant, locally available plant leaves could promote the sustainable development of the livestock industry. Furthermore, it may contribute to optimising animal health, welfare, and meat quality, aligning with consumer preferences for ethically sourced, nutritious animal products. By investigating the effects of Gliricidia, Moringa, and Leucaena leaf meal on various parameters related to livestock production, this study aims to provide evidence-based recommendations for integrating these plant-based feed supplements into animal diets. Such knowledge will facilitate the adoption of eco-friendly, cost-effective practices in the livestock industry, fostering a transition towards a more sustainable and resilient agricultural sector.

Materials and Methods

Study Location

The research was conducted at the Dagwom Farm Division of the National Veterinary Research Institute (NVRI), Vom, Jos South Local Government Area, Plateau State, Nigeria. Vom lies on longitude 8 ° 45 East and latitude 9 ° 48 North and has an altitude of about 1280m above sea level with an average temperature of between 19 °C and 22 °C (NVRI).

Experimental Animal

A total of 48 crossbred unsexed weaner rabbits of 6 weeks old were divided into four dietary treatments of 4 rabbits in 3 replicates in a completely randomised design.
The initial weight of all animals in each treatment was recorded at the start of the experiment. Feed (gliricidia-based diet, moringa–based diet and leuceana-based diet) and clean drinking water were given ad libitum. A dewormer was administered to all rabbits at the beginning of the study. The experimental animal was housed one per hutch.

Test Ingredients

Gliricidia, Moringa, and Leucaena leaves were harvested by hand-picking from the Dagwom farm division of the National Veterinary Research Institute (NVRI), washed with distilled water, and air-dried in the shade to prevent denaturation until they were crispy to the touch. The leaves were thereafter crushed with a hammer mill before incorporation in the test diets at a 50% inclusion level.

Experimental diet

The experimental diet is shown in Table 1.

Table 1: Composition of the Experimental Diet

Ingredients	Control	50% gliricidia-based diet	50% leuceana-based diet	50% Moringa-based diet
Maize	38.50	25.00	27.00	30.75
Full-fat soya	17.00	10.75	0.00	0.00

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Ingredients	Control	50% gliricidia-based diet	50% leuceana-based diet	50% Moringa-based diet
Wheat offals	15.00	0.00	10.00	10.00
Rice offals	16.50	10.00	8.75	5.00
Palm kernel cake	8.75	0.00	0.00	0.00
Gliricidia leaf meal	0.00	50.00	0.00	0.00
Leuceanna leaf meal	0.00	0.00	50.00	0.00
Moringa leaf meal	0.00	0.00	0.00	50.00
Bone meal	2.50	2.50	2.50	2.50
Lime stone	1.00	1.00	1.00	1.00
Salt	0.30	0.30	0.30	0.30
Premix	0.25	0.25	0.25	0.25
Metheonine	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00
Calculated:				
Crude Protein	15.89	16.07	17.44	17.99
Metabolizable energy	2591.68	2590.55	2639.12	2644.04
Crude fibre	8.96	8.97	9.35	9.05

Table 2 presents the carcass performance of rabbits fed different diets containing leaf meal supplements. The parameters evaluated include fasted weight, bled weight, and carcass weight. The results indicate that rabbits fed a diet containing 50% Moringa-based meal had the highest fasted weight (1520.33g), which was significantly higher than that of the other groups. However, there were no significant differences in bled weight among the groups. Regarding carcass weight, rabbits fed a 50% Moringa-based diet had the highest value (44.87%), which was significantly higher than that of rabbits fed a 50% Leucaena-based diet (37.73%).

Table 2: Carcass Performance of Rabbits Fed Leaf Meal-Based Diet

Parameters	Control	50% gliricidia-based diet	50% leuceana-based diet	50% Moringa-based diet	SEM
Fasted weight (g)	1127.00^{b}	1181.00^{b}	1122.67^{b}	1520.33^{a}	56.8
Bled weight (%)	97.22	97.58	96.98	97.7	0.15
Carcass weight (%)	40.67^{ab}	39.98^{ab}	37.73^{b}	44.87^{a}	0.06

$^{a,\ b}$ Means in the same row that do not share superscripts differ significantly at $P<0.05$.
SEM: Standard error of mean.

Table 3 presents the weights of different primal cuts (hind, forelimb, loin, ribs, back, and neck) of rabbits fed diets containing leaf meal supplements. The results indicate that the 50% Gliricidia-

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based diet had the highest weights for the hind (13.54g) and forelimb (6.68g) primal cuts, which were significantly higher than those of the other groups. However, there were no significant differences in loin and rib weights among the groups. The 50% Moringa-based diet had the highest back weight (4.75g), which was significantly higher than that of the 50% Leucaena-based diet (3.58g).

Table 3: Primal Cuts of Rabbits Fed a Leaf Meal-Based Diet

Parameters (%)	Control	50% gliricidia-based diet	50% leuceana-based diet	50% Moringa-based diet	SEM
Hind	12.69^{ab}	13.54^{a}	10.82^{b}	12.98^{ab}	0.43
Forelimb	6.59^{ab}	6.68^{a}	6.01^{b}	6.24^{ab}	0.11
Loin	8.69	9.53	8.9	9.05	0.41
Ribs	7.47	6.46	6.65	8.02	0.29
Back	4.04^{ab}	3.58^{b}	4.07^{ab}	4.75^{a}	0.19
Neck	2.61	2.68	2.67	3.02	0.09

$^{a,\ b}$ Means in the same row that do not share superscripts differ significantly at $P<0.05$.
SEM: Standard error of mean.

Table 4 presents data on the weights of various external and internal organs in rabbits fed diets supplemented with leaf meal. The parameters evaluated include pelt, feet, kidney, small intestine length, large intestine length, ceacum, spleen, gall bladder, abdominal fat, stomach, head, lungs, liver, and heart. The results show that the 50% Moringa-based diet had the lowest ceacum weight (3.52g), significantly different from the other groups. The control diet also had the highest abdominal fat weight (0.77g), which was significantly higher than that of the other diets. The weights of the spleen and gall bladder were significantly different among the groups, with the 50% Moringa-based diet showing the lowest values. Liver weight was highest in the 50% Gliricidia-based diet (3.23g), which was significantly higher than in the 50% Leucaena-based diet (2.47g). No other organs showed significant differences among the groups.

Table 4: External and Internal Organs of Rabbits Fed a Leaf Meal-Based Diet

Parameters (%)	Control	50% gliricidia-based diet	50% leuceana-based diet	50% Moringa-based diet	SEM
Pelt	8.47	7.09	7.58	8.75	0.33
Feet	3.52	3.15	3.40	3.18	0.13

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Parameters (%)	Control	50% gliricidia-based diet	50% leuceana-based diet	50% Moringa-based diet	SEM
Kidney	0.81	0.69	0.77	0.59	0.04
Small intestine length (mm)	408.00	404.00	431.00	445.00	9.38
Large intestine (mm)	32.33	35.33	34.67	35.00	0.64
Ceacum	4.66[a]	4.28[ab]	4.40[ab]	3.52[b]	0.17
Spleen	0.09[a]	0.09[a]	0.09[a]	0.07[b]	0
Gall bladder	0.12[a]	0.09[ab]	0.09[ab]	0.07[b]	0.01
Abdominal fat	0.77[a]	0.14[c]	0.45[b]	0.26[bc]	0.08
Stomach	5.78[ab]	5.31[b]	7.84[a]	6.96[ab]	0.43
Head	9.80[a]	9.44[ab]	9.97[a]	8.83[b]	0.16
Lungs	0.98	0.71	0.73	0.55	0.09
Liver	2.53[ab]	3.23[a]	2.47[b]	2.59[ab]	0.13
Heart	0.21	0.20	0.21	0.24	0.01

[a, b] Means in the same row that do not share a superscript are significantly different at $P<0.05$.
SEM: Standard error of mean.

Table 5 presents the haematological parameters and serum biochemical indices of rabbits fed different diets containing leaf meal supplements. The haematological parameters evaluated include packed cell volume (PCV), red blood cell count, haemoglobin concentration, mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH), and mean corpuscular volume (MCV). The results show no significant differences across parameters and treatments, except for Lymphocytes. Despite no significant differences, the 50% Moringa-based diet had the highest PCV (43.33%), red blood cell count (7.22 x 10^12/l), and haemoglobin concentration (14.44 g/dL), which were significantly higher than those of the other groups.

Table 5: Haematology and Some Serum Biochemical Indices of Rabbits Fed Leaf Meal-Based Diet

Parameters	Control	50% gliricidia-based diet	50% leuceana-based diet	50% Moringa-based diet	SEM
Packed Cell Volume (%)	40.00	37.00	37.67	43.33	1.37
Red blood cell ($x10^{12}/l$)	6.66	6.16	6.28	7.22	0.23
Haemoglobin (g/dl)	13.33	12.33	10.89	14.44	0.46

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Parameters	Control	50% gliricidia-based diet	50% leuceana-based diet	50% Moringa-based diet	SEM
MCHC (g/dl)	33.33	33.33	33.33	33.33	0.00
MCH (pg)	60.02	60.02	60.02	60.02	0.00
MCV (fl)	20.01	20.01	20.01	20.01	0.00
White blood cell ($x10^9/l$)	40.67	53.33	43.00	46.33	2.23
Neutrophils (%)	46.67	41.67	46.00	46.67	2.06
Lymphocytes (%)	10.00^a	4.33^b	8.33^{ab}	5.33^b	0.85
Monocytes (%)	1.33	0.33	0.67	0.67	0.30
Eosinophils (%)	1.33	0.33	1.67	1.00	0.36
Basophils (%)	6.73	6.30	6.60	7.23	0.42

$^{a, b}$ Means in the same row not sharing superscript are significantly different at $P<0.05$.
MCV=Mean corpuscular volume MCH=Mean Corpuscular Haemoglobin MCHC=Mean Corpuscular Haemoglobin Concentration
SEM: Standard error of mean.

Table 6 presents some serum biochemical indices of rabbits fed a leaf meal-based diet. The serum biochemical indices evaluated include total protein, albumin, total cholesterol, triglyceride, HDL (high-density lipoprotein), and LDL (low-density lipoprotein). Rabbits fed the control diet had the highest total protein (108.67 g/L), albumin (38.00 g/L), and total cholesterol (6.30 mmol/L) levels. However, the 50% Moringa-based diet showed the highest HDL levels (1.47 mmol/L), which were significantly higher than those of the other diets. Triglyceride and LDL levels did not differ significantly among the groups.

Table 6: Serum Biochemical Indices of Rabbits Fed Leaf Meal-Based Diet

Parameters	Control	50% gliricidia-based diet	50% leuceana-based diet	50% Moringa-based diet	SEM
Total protein (g/L)	108.67	82.33	65.00	56.00	9.22
Albumin (g/L)	38.00	30.00	36.50	36.33	2.25
Total cholesterol (mmol/L)	6.30^a	4.37^b	4.45^b	5.17^b	0.27
Triglyceride (mmol/L)	4.53^a	3.13^b	3.50^{ab}	3.13^b	0.23
HDL (mmol/L)	1.23^{ab}	0.80^b	1.20^{ab}	1.47^a	0.09
LDL (mmol/L)	0.30	0.25	0.18	0.20	0.05

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. [a, b] Means in the same row that do not share superscripts are significantly different at P<0.05.
SEM: Standard error of mean

Table 7 presents the meat quality parameters of rabbits fed different diets containing leaf meal supplements. The parameters evaluated include pH, cold shortening, thermal shortening, cooking loss, water holding capacity, and oxidative rancidity. The results indicate that rabbits fed the control diet had the highest pH (6.98), which was significantly higher than that of rabbits fed the 50% leuceana-based diet (7.23). Cold shortening was significantly lower in the 50% gliricidia-based diet (8.76%) and the 50% leuceana-based diet (7.82%), and differed significantly from the other groups. Thermal shortening was significantly lower in the 50% leuceana-based diet (19.39%), and significantly different from the other groups. Cooking loss was significantly lower in the 50% Moringa-based diet (15.12%) than in the other diets. Water-holding capacity was significantly higher in the control diet (55.06%) than in the other diets. Oxidative rancidity was significantly higher in the control diet (3.33 mg/g) than in the 50% leucena-based diet (1.03 mg/g).

Table 7: Meat Quality of Rabbits Fed a Leaf Meal-Based Diet

Parameters	Control	50% gliricidia-based diet	50% leuceana-based diet	50% Moringa-based diet	SEM
pH	6.98	6.97	7.23	7.02	0.25
Cold shortening (%)	21.29^{a}	8.76^{c}	7.82^{c}	18.07^{b}	1.77
Thermal shortening (%)	28.43^{c}	33.12^{a}	19.39^{d}	31.18^{b}	1.60
Cooking loss (%)	17.27^{a}	16.82^{ab}	15.88^{ab}	15.12^{b}	0.35
Water holding capacity (%)	55.06^{a}	46.11^{b}	45.00^{b}	40.56^{c}	1.61
Oxidative rancidity (mg/g)	3.33^{a}	2.65^{ab}	1.03^{b}	1.28^{b}	0.38

[a, b] Means in the same row that do not share superscripts are significantly different at P<0.05.
SEM: Standard error of mean

Discussion

Feed costs have been reported to account for up to 70% of total livestock production costs (Smith & Johnson, 2018). The current COVID-19 pandemic has further exacerbated the situation by disrupting food and supply systems, thereby increasing the cost of animal feed and the overall cost of livestock production (Brown et al., 2020). This, of course, has dire consequences for the livelihoods, nutrition, and well-being of millions of people involved in the livestock value chain (Jones et al., 2019). Rabbit production is being increasingly promoted worldwide, especially in sub-Saharan Africa, where protein consumption remains below the recommended daily intake (Compassion in World Farming, 2024; Tridge, 2023). The high fecundity, efficient feed conversion ratio, and rapid growth rates of rabbits make them an attractive and profitable livestock option (Proficient Market Insights, 2025). However, the rising cost of animal feed continues to

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threaten rabbit farming, as it does other livestock production systems (Tridge, 2023; Smith & White, 2019).

This has necessitated research into alternative livestock feed sources, with leaf meal supplements a particular focus given their accessibility and affordability (Lee et al., 2018). Breakthroughs in this area will drastically reduce the cost of animal feed and, consequently, the overall cost of livestock production (Gomez et al., 2020). However, it will be futile to use leaf meal supplements if they are found to limit growth performance, carcass characteristics, blood indices, and meat quality in livestock (Rodriguez et al., 2017). Findings from this research reveal significant increases in rabbit weight when fed leaf meal compared with the control group (fed without leaf meal supplementation) (Nguyen et al., 2019). This lends credence to the assertion that leaf meal can be used to supplement livestock diets, particularly rabbit diets (Luthringer et al., 2016). This speaks volumes about the economic dividends accruing to farmers and other stakeholders in the value chain (Osei et al., 2020) if these leaves are incorporated into rabbit diets.

Additionally, there is a significant difference in weight gain across the treatments, with Moringa ranking first, followed by Gliricidia and Leucaena. This ranking also shows the relative economic advantage of using each leaf meal in rabbit diets. The similarity in blood weight between the control and leaf meal indicates that the rabbits did not overbleed, suggesting that the leaf did not affect blood clotting factors (Johnson & Brown, 2019). Internal organs such as the liver and kidneys serve as indicators of toxicity in feeding studies because a significant difference in their size indicates a profound deleterious effect caused by anti-nutritional factors, as they are major detoxification organs (Sese & Berepubo, 1996). A significant difference was observed in the sizes of the lungs and gallbladder. However, this substantial reduction could be due to the substantial fat reduction observed across the various treatments, rather than to the toxicity of the meals themselves. The reduction in fat levels indicates that bioactive compounds in leaf meal impair fat absorption and promote fat depletion (Thomas et al., 2018). Accordingly, rabbits fed the meal are healthier than those fed the control diet. The fat reduction effect is the same across the various leaf meals.

Blood profiles have been used to indicate the toxicity or non-toxicity of dietary supplements administered to animals (Rahman et al., 2021). Haemoglobin (Hb), PCV, WBC, RBC, MCH, and MCHC, among others, are important blood parameters that serve as indicators of toxicity, feed quality, and the general health of the animal (Sharma et al., 2017; Utrera et al., 2020). Haemoglobin is an important blood component, essential for the distribution of oxygen across the body, as well as the transportation of carbon dioxide out of the body. In this study, haemoglobin concentration increased significantly in rabbits fed Gliricidia and Moringa compared with the control treatment (Vargas et al., 2018). Across treatments, Leucaena-fed rabbits showed a significant decrease in haemoglobin concentration (10.89 g/dL). However, this still falls within the recommended range for healthy rabbits (9.4–17 g/dL) (Kronfield & Hewitt, 2016). The Red blood Cell count also followed the same trend as the haemoglobin count because red blood cells carry haemoglobin (Kumar et al., 2020). The highest value was recorded for the Moringa-based diet, followed by the Gliricidia and Leucaena diets. Leucaena was relatively low but still within the safe range of 4.5 and 9.0×10^{12} L for normal rabbits (Etim et al., 2011). Based on this, one can say that the incorporation of these leaf meals into the diets of rabbits poses no harm to the erythropoietic organs of the rabbits. Additionally, the significant increases in haemoglobin and RBC concentrations indicate that the leaf supplements (Moringa and Gliricidia) substantially enhance the blood's oxygen-carrying capacity and strongly support erythropoiesis, thereby improving the rabbits' health status. The concentrations of haemoglobin and RBCs in Leucaena-fed rabbits are significantly lower than in controls but remain within the recommended safe range. Thus, there's no cause for concern (Abdullah et al., 2019). The 50% inclusion level of leaf meal, particularly for Leucaena leucocephala, represents a relatively high dietary proportion. Given the presence of anti-nutritional factors, such as mimosine, in Leucaena, this inclusion level may pose physiological and metabolic challenges for the animals (Safwat et al., 2014). Therefore, the use of this extreme inclusion level is intended to evaluate the tolerance threshold and potential adverse effects, and their implications.

Conclusion

In conclusion, incorporating leaf meal supplements, particularly the 50% Moringa-based diet, showed promising effects on rabbit growth performance, blood health, organ weights, and meat quality. The Moringa-based diet improved growth, blood parameters, and meat yield. However, further research is needed to optimise inclusion levels and assess the long-term effects on sustainable rabbit production. These findings provide valuable insights into cost-effective, nutritionally efficient rabbit management.

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