International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 1s, 2025
https://www.theaspd.com/ijes.php

Moringa oleifera Leaf Meal as a Natural Alternative Feed: Effects on Blood Profile, Production Performance, and Egg Quality of Layer

Eni Dwi Karmiyantiningsih[1], Zuprizal[2], Heru Sasongko[3]*
[1] Postgraduate Program in Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia
[2] Department of Animal Nutrition and Feed Science, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia
[3] Department of Animal Production, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia
*Corresponding Author: herusasongko@ugm.ac.id

Abstract: *Moringa oleifera is a nutrient-rich plant with bioactive compounds that can enhance poultry productivity and egg quality. This study evaluated the effects of moringa leaf meal (MLM) as a feed substitute (up to 10%) on blood profile, production performance, and egg quality in laying hens. A completely randomized design (CRD) was applied with five dietary treatments: P0 (control), P2.5 (2.5% substitution), P5 (5%), P7.5 (7.5%), and P10 (10%). Data collected included blood parameters, production performance, egg quality, and yolk cholesterol levels. Statistical analysis using ANOVA showed that MLM up to 10% had no significant impact ($P > 0.05$) on erythrocyte count, platelet count, leukocyte count, or hematocrit levels, indicating that it does not compromise hen health. However, there was a significant decrease in feed consumption ($P < 0.05$), likely due to higher fiber content. Additionally, MLM enhanced yolk pigmentation and reduced yolk cholesterol ($P < 0.05$). These findings suggest that MLM is a promising feed alternative that enhances egg quality without compromising hen performance. From a global perspective, incorporating alternative feed sources like MLM can reduce dependence on conventional ingredients such as soybean meal and corn, which are subject to price fluctuations and environmental concerns. This approach supports sustainable poultry production by lowering feed costs, utilizing locally available resources, and promoting eco-friendly farming practices.*

Keywords: Moringa oleifera, natural alternative feed, blood profile, egg cholesterol reduction, sustainable poultry production

INTRODUCTION

Eggs are a primary and affordable source of animal protein globally, including in Indonesia. In addition to chicken eggs, duck and quail eggs are also widely consumed. Economic growth has contributed to increased purchasing power, leading to higher demand for nutritious foods, particularly animal protein sources that are relatively inexpensive and readily available. Poultry products, especially eggs, are an essential component of human nutrition due to their high biological value and affordability compared to other protein sources like beef and milk (FAO, 2021).

To meet the increasing demand for animal protein, the expansion and optimization of layer farming are necessary. The poultry industry has spread across all regions, with continuous improvements in farm management, feed quality, and farming technology playing a crucial role in production efficiency. Feed costs account for approximately 70–75% of total production expenses in poultry farming (Amrullah, 2014), making the search for cost-effective and nutritionally adequate alternative feed sources essential for industry sustainability.

One approach to reducing feed costs without compromising nutritional quality is the incorporation of alternative feed ingredients such as plant-based meals. Moringa oleifera leaf meal (MLM) is a promising alternative due to its rich nutrient profile, including proteins, essential amino acids, vitamins, and minerals, as well as bioactive compounds with antioxidant properties (Makkar & Becker, 1996; Gopalakrishnan et al., 2016). Research has shown that phytochemical compounds in Moringa leaves can enhance animal health by improving blood parameters, such as erythrocyte, leukocyte, platelet, and hematocrit levels (Fahey, 2005).

Globally, the use of plant-based feed additives is gaining traction as the livestock industry shifts towards sustainable and environmentally friendly practices. Several studies in Africa, Asia, and Latin America have explored the potential of MLM as a feed supplement. In Nigeria,

MLM inclusion in poultry diets improved feed efficiency and reduced production costs (Olugbemi et al., 2010). In Ethiopia, Tesfaye et al. (2014) reported that MLM supplementation enhanced egg quality, particularly yolk pigmentation. Similarly, in India, Panda (2018) found that MLM improved egg production and nutrient retention in laying hens.

In addition to production benefits, MLM has been found to lower egg cholesterol levels, contributing to healthier poultry products (Bukar et al., 2010; Zulfiana et al., 2017). This aspect is particularly relevant given the growing consumer preference for functional foods with health benefits. Moreover, incorporating MLM into poultry diets can reduce reliance on conventional feed ingredients like soybean meal and maize, which are subject to price volatility and environmental concerns (Tesfaye et al., 2014; Hadrawi et al., 2022).

Previous studies on the utilization of Moringa oleifera in poultry feed have primarily focused on production performance and feed efficiency, while aspects related to poultry health and egg quality have not been comprehensively explored. Therefore, this study aims to thoroughly evaluate the effects of using MLM as a substitute feed ingredient at inclusion levels of up to 10% on the blood profile, production performance, and egg quality of laying hens. By understanding the impact of MLM not only on production performance but also on blood health parameters and egg quality, this research is expected to provide a scientific basis for the use of alternative feed ingredients that are more economically viable and sustainable. Furthermore, the findings of this study can contribute to the development of a more efficient poultry farming system, particularly in addressing the challenges of fluctuating prices for conventional feed ingredients such as maize and soybean meal, while supporting eco-friendly poultry production practices.

1. MATERIALS AND METHODS

Ethical Approval

Ethical approval was obtained from the Research Ethics Commission Board of the Faculty of Veterinary Medicine, Universitas Gadjah Mada (Approval No. 31/EC-FKH/int/2024). Layer were kept at the Experimental at an experimental facility in Yogyakarta, Indonesia. Meanwhile, tests related to the research were conducted at the Laboratory of Faculty of Animal Science UGM, Yogyakarta.

Layer

The layer that used in the research were Isa Brown with an age of 35 weeks totaling 100 hens and produced by PT Charoen Pokphand, Semarang.

Feed

The layer concentrate used was K 204 X-TRA, from PT Sierad Sidoarjo, with a mixture of concentrate, corn and rice bran in the ratio of 35:30:35, given twice a day. Drinking water was always available at all times (ad libitum) where the tool used was a nipple-shaped drinker. The experimental diets consisted of five treatments with varying levels of MLM substitution (0%, 2.5%, 5%, 7.5%, and 10%), replacing a portion of the commercial concentrate while maintaining consistent levels of other ingredients such as corn and rice bran. The complete feed compositions for each treatment are presented in Table 1. The nutrient composition of the experimental diets was analyzed using proximate analysis at the Laboratory of Animal Nutrition and Diet, Faculty of Animal Science, Universitas Gadjah Mada. The results, presented in Table 2, indicate that the inclusion of MLM slightly reduced crude protein (CP) content and metabolizable energy (ME) values, while crude fiber (CF) levels increased as MLM levels rose. These changes are attributed to the higher fiber content of Moringa leaves compared to conventional concentrate feed. The reduction in lipid content with increasing MLM levels is likely due to the lower fat content of Moringa leaves compared to commercial concentrates. However, calcium (Ca) and phosphorus (P) levels remained relatively stable across treatments, ensuring adequate mineral availability for optimal egg production and shell

quality. The proximate analysis results confirm that MLM can be incorporated into layer diets without compromising essential nutrient balance, making it a viable alternative feed ingredient for sustainable poultry production.

Cage

The cages used are battery system chicken cages made of bamboo with a size of 40 cm x 50 cm arranged in two levels, feed bins made of PVC pipe material which is split in the middle into two parts to form a cylinder, egg racks for eggs, electric scales with an accuracy level of 0.01g, and additional equipment such as egg quality test equipment in the form of a blender, vernier, depth micrometer, yolk separator, three legs, tray, yolk colour fan, stationery, bucket, ruler, petri dish, and blood profile test equipment to measure erythrocytes, hematocrit, leukocytes, and platelets.

Blood profile

At the end of the treatment period, blood samples were taken to measure various blood components. The blood was drawn from a vein under the wing using a 3 cc syringe and then placed in a tube containing heparin to prevent clotting. The collected blood samples were then analyzed to measure white blood cell (leukocyte) count, red blood cell (erythrocyte) count, hematocrit level (percentage of red blood cells), and platelet count. Erythrocyte and leukocyte levels were measured using the hemocytometer method (Habiyah, 2015), while hematocrit levels were measured with a hematocrit microcapillary reader, and platelet levels were measured using the Giemsa staining method (Krisnawati and Hardisari, 2015).

Performance production.

Observations on performance production include:

a. Feed consumption

Feed consumption in layer obtained by subtracting the total amount of feed given to the chickens from the remaining feed and wasted feed. Calculation of feed consumption in grams per chicken. Feed consumption= (Total feed given to chickens) - (left over feed + uneaten or wasted feed)

b. Egg production

Calculation of egg production using the Hen Day Production formula. Calculation by comparing the amount of egg production obtained with the total number of layer (tails) kept then multiplied by 100%. Calculation of *Hen Day Production* in chickens by means of: HDP = (total egg production / total live hens when kept) x 100%

c. Feed conversion

Feed conversion in chickens is calculated by comparing the amount of feed eaten by chickens in grams with the weight of eggs in grams.

d. Income Over Feed Cost

Income Over feed Cost (IOFC) is obtained by subtracting feed costs from income from egg sales. The formula for calculating IOFC is as follows,

Income Over Feed Cost / IOFC (Rp / g) = (weight of chicken eggs in grams x selling price of chicken eggs /kg) - (feed consumption in grams x cost of chicken feed / kg)

Chicken egg quality observations made include:

a. Egg index

Calculation of egg index using the following formula = chicken egg width (cm) / chicken egg length (cm)

b. Egg weight (g)

Measurement of egg weight by weighing the total number of eggs produced per day during the study. The unit for egg weight is gram

c. Yolk colour

Roche Yolk Colour Fan is used to measure the colour intensity of chicken egg yolk, the yolk colour is measured by breaking the egg on a glass plate table, then comparing the yolk colour with the colour on the Roche Yolk Colour Fan which has a colour score from 1 to 15.

d. Shell weight.

The weight of the shell can be calculated by weighing the shell that has been separated from the egg white and yolk. The shells have previously been aerated in advance to reduce the water content. The tool used to weigh the shells is Ohaus 310 scales with an accuracy of 0.1 gram.

e. Thickness of the shell

Measurement of egg shell thickness is done by removing the skin or thin membrane inside the egg shell and measuring the thickness of the shell, the unit for shell thickness is mm. The tool used to measure the thickness of the shell is a micrometer.

f. Yolk index.

The yolk index measurement step is calculated by separating the yolk part from the egg white, the yolk part of the chicken egg is placed on a flat glass plate, then the height of the yolk and the diameter of the yolk are calculated. Yolk index formula = (yolk height measurement) / (yolk width measurement)

g. Egg yolk cholesterol

The cholesterol content of chicken egg yolk was tested at the Laboratory of the Faculty of Animal Science, UGM. The cholesterol levels were measured using a spectrophotometer (ICNND, 1963) with the following procedure: First, 0.1 gram of egg yolk was weighed, and

0.1 ml of distilled water was prepared as a blank sample. Next, 1 ml of 33% alcoholic KOH was added and mixed continuously until a clot formed. The clot was then placed in a water bath at 39-40°C for 1 hour. Afterward, 4 ml of PE solution (400–600°C) was added to the clot. In the standard series, 2 ml of PE solution was added, followed by 0.25 ml of H_2O. The mixture was shaken for 1 minute and centrifuged. Using a pipette, 200 μl of the sample and standard solution were transferred to a boiling stone and stored in a water bath at 80°C for 2 minutes. The mixture was then dried in an oven at 105-110°C for approximately 35 minutes and allowed to cool to room temperature. Afterward, 4 ml of acetic-sulfuric acid was added, the mixture was shaken, and allowed to stand for 35 minutes. Finally, the results were measured using a spectrophotometer at a 630 nm wave length.

Data Analysis

The data obtained from the study were analyzed using statistical methods with ANOVA (Analysis of Variance) based on a one-way Completely Randomized Design (CRD). If significant or highly significant differences were found from the analysis, further testing was conducted using Duncan's New Multiple Range Test (DMRT) to determine which groups were different (Astuti, 2007). Statistical analysis was conducted using IBM SPSS Statistics version 26.

2. RESULTS

Blood Profile

Blood profile measurements including leukocyte, platelet, erythrocyte, and hematocrit levels are presented in Table 3. Overall, MLM used in the study up to 10% level did not significantly differ in the number of leukocytes, platelets, erythrocytes and hematocrit ($P > 0.05$). This can be interpreted that the provision MLM up to 10% usage level does not have a negative impact on the blood health status of layer, therefore MLM can be used as a feed additive that does not interfere with hematological parameters. The average leucocyte levels ranged from 23.38 to

23.76×10^3/ml, which is still within normal limits for layer, while for platelet levels there was no significant effect ($P > 0.05$) on blood platelet levels, with average values ranging from 24.8 to 25.2×10^3/µl, which is within normal limits. Likewise, the test results for erythrocyte and hematocrit levels also had no significant effect ($P>0.05$) where erythrocyte levels ranged from

2.70 to 2.73×10^6/ml and hematocrit levels ranged from 30.3% to 30.7%.

Production Performance of Layer

Data collected for measuring production performance include feed consumption, egg production, feed conversion, and Income Over Feed Cost (IOFC), as presented in Table 4. Feed consumption data showed a significant difference ($P < 0.05$) between treatments. However, the percentage of egg production, feed conversion, and IOFC values did not show significant differences ($P > 0.05$). The reduction in feed consumption observed in this study is likely related to the increased crude fiber content in the feed containing moringa leaf meal (MLM). Despite the decrease in feed consumption, feed conversion and feed efficiency values tended to increase numerically with the increasing levels of MLM used. However, these differences were not statistically significant. This suggests that although changes in feed consumption and feed efficiency occurred, their impact on egg production performance and IOFC values was not large enough to show significant changes.

Egg Quality of Layer

Utilization of MLM in layer diets up to a 10% level resulted in a significant increase in egg yolk color and a significant decrease in egg yolk cholesterol ($P < 0.05$), as shown in Table 5 and Table 6. These findings suggest that the inclusion of MLM may positively influence the pigmentation of egg yolks, likely due to its high content of carotenoids, which are known to enhance yolk color. In addition, the reduction in yolk cholesterol levels may be attributed to the bioactive compounds present in MLM, which may contribute to improved lipid metabolism in the hens. However, the overall utilization of MLM up to the 10% level did not significantly affect the average egg weight, egg index, egg shell weight, egg shell thickness, or egg yolk index ($P > 0.05$). Despite these results, the use of MLM at the 10% level produced the highest yolk color intensity compared to other treatments, and the lowest yolk cholesterol levels. Interestingly, although there was a decrease in egg index, egg shell weight, and yolk index, the values for egg weight and egg shell thickness increased numerically with increasing MLM inclusion levels. However, these differences were not statistically significant. This indicates that while MLM improved egg yolk characteristics, its impact on other quality parameters such as egg weight and shell traits was minimal, and further investigation may be needed to explore its potential effects on these parameters.

3. DISCUSSION

This study shows that the use of MLM in the feed mixture for laying hens up to a level of 10% has a positive impact on the blood profile, demonstrating that MLM is safe and does not disrupt the blood health status or hematological parameters of laying hens. These results are in line with Rahmawati et al. (2021), who stated that modifications in feed composition, especially with additives like moringa leaves, do not always have a significant effect on hematocrit levels or other hematological parameters when hens are in good physiological condition. Additionally, other factors contributing to the absence of significant differences in leukocyte, erythrocyte, and thrombocyte levels include environmental and genetic factors. According to Lestari et al. (2021), environmental and genetic factors also influence leukocyte count. The lack of significant differences in leukocyte counts between treatment groups could also be due to stable and uniform environmental conditions during the study. The absence of significant differences in platelet levels across treatments may be due to the homeostasis mechanisms in hens that maintain hematological parameter stability, including platelet levels (Akhirudin & Wibowo, 2022). This homeostasis allows hens to maintain platelet counts even with changes in feed composition. The limited effect of MLM on platelet levels at the tested concentrations might also be due to the balanced nutritional content of the basic feed. Although MLM is known for its good nutritional content, such as vitamins and minerals, its impact on platelet levels may not be significant at the tested concentrations.

Previous research in Africa and Latin America has also shown that the use of moringa leaves in livestock feed has the potential to improve livestock health and productivity. In Africa, for example, Melesse et al. (2013) found that moringa can improve growth and disease resistance in livestock due to its protein and antioxidant content. In addition, the use of moringa leaves in Latin America has been reported to improve feed efficiency in broiler chickens, contributing to significant feed cost reductions (Melesse et al., 2013). Therefore, the potential of moringa as livestock feed is not limited to Indonesia but also has a positive impact globally, especially in reducing feed costs and improving the sustainability of livestock production.

The use of MLM in animal feed has significant potential to reduce feed costs in the global poultry industry. Additionally, since moringa is a fast-growing plant with excellent nutritional content, its use can reduce reliance on imported feed and support sustainable, environmentally- friendly agricultural systems. In the long term, this reduction in feed costs could contribute to increased economic efficiency in the global poultry industry, particularly in developing countries. On the other hand, wider moringa cultivation could help reduce carbon emissions, as moringa is a drought-tolerant plant that also helps reduce soil erosion (Foidl et al., 2001).

This study has some limitations that should be considered. One of these is the relatively small sample size, which may affect the generalizability of the results. Additionally, the short duration of the study only provides an overview of the short-term effects of moringa leaf flour in laying hen feed. Further research with a larger sample size and longer duration is needed to assess the long-term effects and potential of moringa on laying hen productivity and hematological parameters.

This study also indicates that the use of moringa leaf flour (MLM) in the feed mixture for laying hens up to a level of 10% does not negatively affect egg production, feed efficiency, or IOFC. However, the feed consumption data showed a decrease in feed intake as the level of MLM increased. The reduction in feed consumption in laying hens is likely due to the increased fiber content, which may reduce digestion rates and nutrient availability. This is in line with Wati et al. (2018), who stated that increased fiber content in feed can reduce feed intake in chickens. The fiber in the feed can fill the digestive tract, slowing the movement of food and causing the hens to feel full more quickly, thus reducing feed intake. According to Hetland et al. (2003), increasing fiber content in feed tends to reduce feed consumption by slowing food transit rates in the digestive tract, making hens feel full faster. Besides the high fiber content, decreased feed consumption may also be caused by anti-nutritional factors such as saponins or tannins, which can reduce feed palatability, making hens reluctant to consume sufficient feed (Olugbemi et al., 2010). Nonetheless, the use of moringa leaf flour up to 10% is still within the average feed consumption range for Isa Brown hens, which is 105g - 115g per hen per day (Pilliang, 2004). This is in agreement with Hetland et al. (2003), who noted that higher fiber content in feed tends to reduce feed consumption by slowing food transit in the digestive tract, causing hens to feel full faster.

The use of MLM in the feed mixture can improve feed efficiency, although the results were not statistically significant. This is likely due to the high-quality nutrient content in moringa leaves, especially proteins, vitamins, and antioxidants, which can improve metabolism and overall hen health (Melesse et al., 2013). The protein content in moringa helps improve protein metabolism in hens, making the feed more efficient for egg production. Additionally, antioxidants in moringa help maintain cell health and improve nutrient utilization efficiency (Foidl et al., 2001). The use of MLM in the feed mixture did not affect IOFC, possibly due to the relatively stable egg prices during the study (Satria E, 2017). During the study, egg prices were stable, so the impact of feed formulation changes on income was not significant. Another factor influencing IOFC is the consistent feed efficiency. According to Panda (2018), although moringa leaf flour was incorporated into the feed, feed efficiency remained consistent across treatment groups. If feed conversion between control and treatment groups did not differ significantly, the conversion of feed into eggs remains efficient despite feed composition changes, which contributes to IOFC stability. The use of MLM up to 10% in the feed mixture for layer had a significant effect on egg yolk color and egg yolk cholesterol levels. However, parameters such as egg weight, egg index, shell weight, shell thickness, and yolk index did not show significant effects. The presence of moringa leaf flour in the feed mixture influences an increase in vitamin A and vitamin C content, which in turn enhances the consumption of these vitamins. Moringa. MLM contains ß-carotene, which acts as a precursor to vitamin A, a key pigment source for egg yolks. Consumers tend to prefer eggs with a more intense yellow yolk color, as it is often considered a quality indicator. Increasing the amount of moringa leaf flour in the feed enhances the amount of vitamin A and ß-carotene deposited in the egg yolk. Higher carotenoid content in the feed contributes to the accumulation of pigment in the yolk, resulting in a more intense yellow color (Kakengi et al., 2007). Previous studies have also shown that increased intake of natural pigments like lutein and zeaxanthin from feed sources like moringa leaves can intensify egg yolk color (Rahman et al., 2022).

The reduction in cholesterol levels in the yolk of eggs fed with 10% MLM is due to the high fiber content in the feed mixture. Fiber speeds up food transit time and also acts as a bile acid binder, which helps absorb fat, thus promoting the excretion of fat, including cholesterol, through feces. Rahman et al. (2022) stated that high fiber content in the feed can enhance fat excretion through feces, including cholesterol. The reduction in cholesterol levels in eggs with 10% moringa leaf flour is not only due to the fiber content but may also be influenced by the vitamin C content in moringa leaves. Vitamin C enhances the production of enzymes that break down triglycerides, reducing triglyceride levels in the serum while strengthening cell walls through collagen and mucopolysaccharide synthesis (Piliang, 2004; Satria, 2017). Furthermore, the presence of saponins, which have detergent-like properties, also reduces cholesterol absorption, thereby reducing the amount of cholesterol entering the body. This is in line with Sarfatayat (2019), who noted that vitamin C contributes to cholesterol metabolism through the following mechanisms: 1) accelerating cholesterol excretion as bile acids, 2) increasing HDL levels to remove LDL cholesterol, and 3) acting as a laxative to increase fecal output, reducing the reabsorption of bile acids that can be converted into cholesterol. Olugbemi et al. (2010) stated that saponins can lower cholesterol by inhibiting its absorption and increasing excretion, which directly reduces cholesterol levels in the body. The reduction in cholesterol levels in egg yolks is caused by a combination of vitamin C, fiber, and saponins found in moringa leaves (Bukar et al., 2010). Adding up to 10% moringa leaf flour did not affect egg weight, egg shape, shell quality, or yolk quality, as the essential nutrients in moringa maintain the nutritional balance required by hens to sustain egg quality.

4. CONCLUSIONS

The use of moringa leaf meal (MLM) up to 10% in the feed for Isa Brown layer hens has no negative impact on blood profile, production performance, or egg quality. On the contrary, MLM improves yolk color intensity and reduces cholesterol levels in the yolk. Therefore, MLM can be used up to 10% in poultry feed as an effective, economical, and sustainable alternative. This use of MLM can also reduce dependence on imported feed, providing long- term economic and environmental benefits.

ACKNOWLEDGEMENTS

We would like to express our gratitude and appreciation to the Animal Nutrition and Diet Laboratory, Department of Animal Nutrition and Diet Science, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia, for providing laboratory facilities. We also thank SMK Negeri 1 Cangkringan for providing research facilities that support the implementation of this study.

AUTHOR'S CONTRIBUTION

Eni Dwi Karmiyantiningsih: Collected and analyzed data, and drafted the script. Heru Sasongko: Drafting the research concept and modifying the script. Zuprizal: Provided research ideas, supervised experiments, and revised the script.

CONFLICT OF INTEREST

All authors confirm that they have no competing interests.

REFERENCES

Akhirudin, A., & Wibowo, H. 2022. Effect of supplementary feeding on haematological quality of layer. Indonesian Journal of Animal Science, 15(2), 124-132

Amrullah, I. K. 2014. Broiler and Layer Chicken Nutrition. Yogyakarta: Gadjah Mada University Press.

AOAC. 2012. Official Methods of Analysis of AOAC International (19th ed.). Gaithersburg, MD: AOAC International.

Astuti, D. A.2007. Practical statistics guide for animal science. Yogyakarta: Gadjah Mada University Press.

Bharali, R. 2013. Chemical and pharmacological evaluation of Moringa oleifera Lam.: a review. International Journal of Pharmacy & Life Sciences, 4, 2789-2798.

Bukar, A., Uba, A., & Oyeyi, T. 2010. Antimicrobial Profile of Moringa oleifera Lam Extracts Against Some Food-Borne Microorganisms. Bayero Journal of Pure and Applied Sciences, 3, 43-48.

Dwi, S. 2012. Factors affecting yolk index in layer. Journal of Animal Nutrition, 7(2), 98-107. Erniasih, N., & Saraswati, M. 2006. Amino Acid Intake for Leukocyte Formation. Jakarta:

University of Indonesia Press.

Etim, N. N., Williams, M. E., Akpabio, U., & Offiong, E. E. A. 2014. Hematological Parameters:

Indicators of the Physiological Status of Farm Animals. British Journal of Poultry Science, 3(1), 16-24.

Fahey, J. W. 2005. Moringa oleifera: A review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. Trees for Life Journal, 1(5), 1-15.

Falahudin, A., Wahyono, F., & Syarifuddin, A. 2016. Effect of Environmental Stress on the Increase of Leukocytes in Poultry. Journal of Animal Science, 14, 45-52.

Food and Agriculture Organization. 2021. FAO Dairy Mark Review: Overview of global dairy market developments in 2020. *FAO. https://www.fao.org/3/cb4230en/cb4230en.pdf*

Foidl, N., Makkar, H. P. S., & Becker, K. 2001. The potential of Moringa oleifera for agricultural and industrial uses. In The Miracle Tree: The Multiple Attributes of Moringa

pp. 45-76. Church World Service.

Ghosh, A., et al. 2018. Haematological parameters in poultry. Veterinary World, 11, 510- 514.

Gopalakrishnan, L., Doriya, K., & Kumar, D. S. 2016. Moringa oleifera: A review on nutritive importance and its medicinal applications. Food Science and Human Wellness, 5(2), 49- 56.

Goyal, M., et al. 2018. Nutritional and therapeutic value of Moringa oleifera. Indian Journal of Animal Research, 52(8), 1190-1197.

Habiyah, N. 2015. Introduction to veterinary haematology. Yogyakarta: Faculty of Veterinary Medicine, Gadjah Mada University.

Hadrawi, J., Pitres, S. P., & Basri. 2022. Effects of Moringa (Moringa oleifera) Leaf Meal Supplementation on Production Performance and Egg Quality of Layer. Journal of Animal Science and Technology, 3(2), 43-48.

Hetland, H., Svihus, B., & Krogdahl, A. 2003. Effects of oat hulls on performance, gut capacity and feed passage time in broiler chickens. British Poultry Science, 44(5), 837- 844.

Isroli, I., Susanti, T., & Murtini, S. 2009. The Role of Leukocytes in the Immune System in Poultry. Journal of Animal Health, 3(1), 12-19.

Jannah, N., Rahayu, S., & Pranoto, T. 2017. Leukocyte count and health of layer. Journal of Poultry Science, 5(3), 32-39.

Krisnawati, A., & Hardisari, R. 2015. Haematological and blood biochemical tests in determining the health status of layer. Journal of Livestock and Veterinary Sciences, 20(3), 169-175.

Kakengi, A. M. V., Shem, M. N., Sarwatt, S. V., & Mtengeti, E. J. 2019. Effects of Moringa oleifera leaf meal as a substitute for sunflower seed meal on the performance of layer. Livestock Research for Rural Development, 31(12).

Lestari, D., Nurhayati, N., & Sari, M. 2021. Genetic and environmental factors influencing haematological parameters in poultry. Poultry Science Journal, 29(3), 221-227.

Lesson, S., & Summers, J. D. 2001. Nutritional Factors Affecting Egg Production and Quality in Layer. University of Guelph Press.

Makkar, H. P. S., & Becker, K. 1996. Nutritional value and antinutritional components of whole and ethanol extracted Moringa oleifera leaves. Animal Feed Science and Technology, 63(1-4), 211-228.

Melesse, A., Bulang, M., & Kluth, H. 2015. Effect of Moringa (Moringa oleifera) leaf meal inclusion in broiler diets on nutrient efficiency and performance. Tropical Animal Health and Production, 47(5), 797-806. https://doi.org/10.1007/s11250-015-0814-x

Mohammed, A. M., Al-Hussaini, H., & Ahmad, H. 2022. Haematological parameters in layers: A review. Veterinary World, 15(1), 54-63.

Olugbemi, T. S., Mutayoba, S. K., & Lekule, F. P. 2010. Antinutritional factors in Moringa oleifera and effects on poultry performance. World's Poultry Science Journal, 75(2), 181-192.

https://doi.org/10.1017/S0043933919000096

Panda, M. 2018. Response of Moringa leaf meallin Layers' Feed to Production Performance and Egg Quality. Journal of Animal Science, 3(1), 25-32.

Pilliang, W. G. 2004. Poultry Livestock Science. Gadjah Mada University Press.

Putri, R. A., Yulianti, N., & Suryaningsih, A. 2020. The impact of high dietary fibre on feed consumption and digestibility in layer. Poultry Science Research, 48(6), 356-362.

Rahman, A. Z., Subhan, A., & Akbar, M. A. 2022. Evaluation of haematological and biochemical parameters in layer fed with Moringa oleifera-supplemented diets. Veterinary Research Communications, 46(1), 145-152. https://doi.org/10.1007/s11259- 022-09876-y

Rahmawati, D., Syamsuddin, A., & Wijaya, T. 2021. Effect of natural supplements on haematological parameters in layer. Agripet Journal, 20(1), 65-72.

Sarfatayat, A., Budiatmaja, I. P., & Noer, H. M. 2019. Effect of vitamin C on cholesterol metabolism and increased HDL levels. Journal of Health Research, 7(2), 123-135.

Satria, E. W. 2017. Response of Moringa (Moringa oleifera) Leaf Meal in Feed to Production Performance and Egg Quality of Layer. Master's Thesis, Brawijaya University

Safitri, R., Dewi, K. S., & Wahyuni, S. 2023. Economic analysis of feed formulations in layer: Impact on IOFC. Asian Journal of Poultry Science, 17(2), 89-96.

Tesfaye, E., Tamir, B., & Dessie, T. 2014. Moringa oleifera leaf meal as an alternative protein feed ingredient in poultry ration: Effects on growth performance, carcass characteristics, and blood parameters. Livestock Research for Rural Development, 26(3), 53-60.

Zulfiana, E., Nurdin, R., & Supriadi. 2017. Effect of Moringa (Moringa oleifera) Extract on Reducing Cholesterol Levels in Blood of Mice (Mus musculus). J. Akademika Kim, 6(1), 15-20.

Appendix:

Table 1. Feed nutrient content and ration composition of feed

	Treatment				
	T0(%)	T2.5(%)	T5(%)	T7.5(%)	T10(%)
Corn	30	30	30	30	30
Bran	35	35	35	35	35
Concentrate Feed	35	32.5	30	27.5	25
Moringa leaf meal(MLM)	0	2.5	5	7.5	10
TOTAL	100	100	100	100	100
Nutrient content	Feed Treatment				
Metabolizable Energy (kcal/kg)	2809.65	2780.69	2778.33	2773.14	2770.89
Crude Protein (%)	20.78	19.68	19.36	19.13	19.09
Crude Fiber (%)	5.19	5.32	5.43	6.08	6.16
Crude Fat (%)	4.28	3.99	3.89	3.80	3.67
Calcium (Ca) (%)	3.87	3.85	3.83	3.81	3.82
Phosphorus(%)	0.87	0.84	0.84	0.82	0.81

Description: Analysis results of Animal Nutrition and Feed Science Laboratory Faculty of Animal Science Gadjah Mada University

Tabel 2. Composition and nutrient content Basal Feed

Component	CP (%)	CF(%)	CF(%)	Ca(%)	P(%)	ME (kcal/kg)
Maize[a]	8.6	4	2.2	0.02	0.23	3370
Bran[a]	10.2	4.2	12	0.2	1.0	2860
Concentrate[b]	35	6.3	3.83	3.5	0.45	2747
MLM[c]	31.29	5.19	6.41	2.09	0.67	2440

Source: a). Revelation 2017

b). Sierad Produce brochure

c). Proximate Analysis Lab Animal Nutrition and Diet Gadjah Mada University

Note : CP: Crude Protein; CF :Crude Fat; CF : Crude Fiber, Ca: Calcium; P: Phosphorus

ME : Metabolizable Energy

Table 3. Effect of moringa leaf meal on blood profile

Treatment	Leukocytes ($\times 10^3$/ml).	Platelets ($\times 10^3$/ml)	Erythrocytes ($\times 10^6$/ml)	Hematocrit (%)
T0	23.48 ± 1.29	27.0 ± 1.2	2.50 ± 0.10	30.5 ± 1,2
T2.5	23.76 ± 0.57	27.1 ± 1.2	2.52 ± 0.12	30.3 ± 1,3
T5	23.53 ± 2.70	27.2 ± 1.1	2.51 ± 0.11	30.7 ± 1,1
T7.5	23.42 ± 0.81	27.3 ± 1.4	2.53 ± 0.13	30.6 ± 1,4
T10	23.38 ± 0.50	27.1 ± 1.2	2.54 ± 0.13	30.4 ± 1,2

Description: T0: addition of 0% MLM, T2.5: addition of 2.5% MLM, T5: addition of 5% MLM, T7.5: 7.5% addition of MLM, T10: 10% addition of MLM. Different notations in the same column of the table indicate significant differences (* for P value <0.05).

Table 4. Effect of using moringa leaf meal on production performance

Treatment	Feed consumption (g/head/day)	HDP (%)	Feed conversion	IOFC (Rp/head)
T0	119.00 ± 0.10 ^{ab}	88.62 ± 1.97	1.98 ± 0.02	4055.72 ± 1.24
T2.5	118.79 ± 0.45^{b}	88.06 ± 0.03	1.97 ± 0.01	4081.29 ± 1.42
T5	118.55 ± 0.05^{b}	89.15 ± 0.01	1.92 ± 0.07	4179.82 ± 23.2
T7.5	117.76 ± 0.45^{a}	88.81 ± 0.04	1.87 ± 0.06	4120.90 ± 48.1
T10	117.24 ± 0.21^{a}	89.03 ± 0.03	1.87 ± 0.02	4162.07 ± 42.5

Description: P0: addition of 0% MLM, P1: addition of 2.5% MLM, P2: addition of 5% MLM, P3: 7.5% addition of MLM, P4: 10% addition of MLM. Different notations in the same column of the table indicate significant differences (* for P value

<0.05).

Note :HDP : Hen Day Production; IOFC : Income Over Feed Cost

Table 5. Effect of using moringa leaf meal on egg quality

Treatment	Egg weight (g)	Shell weight (g)	Thickness of the shell (mm)	Egg yolk index	Egg index (%)	Egg yolk colour
T0	59.54 ± 0.01	8.04 ± 0.00	0.33 ± 0.01	0.40 ± 0.01	74.43 ± 0.01	7.38 ± 0.09^{a}
T2.5	60.27 ± 0.02	8.03 ± 0.01	0.33 ± 0.02	0.41 ± 0.02	74.33 ± 0.05	8.61 ± 0.25^{ab}
T5	60.72 ± 0.02	7.95 ± 0.04	0.34 ± 0.02	0.40 ± 0.01	74.40 ± 0.02	11.11 ± 0.50^{bc}
T7.5	61.62 ± 0.01	7.93 ± 0.02	0.34 ± 0.08	0.40 ± 0.01	74.25 ± 0.02	11.50 ± 0.16^{bc}
T10	61.36 ± 0.02	7.94 ± 0.05	0.34 ± 0.04	0.40 ± 0.01	74.39 ± 0.02	13.16 ± 0.16^{c}

Description: T0: 0% MLM addition, T2.5: 2.5% MLM addition, T5: 5% MLM addition, T7.5: 7.5% addition of MLM, T10: 10% addition of MLM. Different notations in the same column indicate significant differences (* for P value <0.05).

Table 6. Effect of using moringa leaf meal on egg yolk cholesterol

Treatment	Cholesterol (mg/100g)
T0	233.40±1.55 ^{c}
T2.5	232.69±1.15 ^{c}
T5	229.36±0.94 ^{b}
T7.5	228.50±0.89 ^{ab}
T10	227.64±0.31 ^{a}

Description: P0: 0% MLM addition, P2.5: 2.5% MLM addition, P5: 5% MLM addition, P7.5: 7.5% addition of MLM, P10: 10% addition of MLM. Different notations in the same column indicate the results of significant differences (* for P value <0.05).

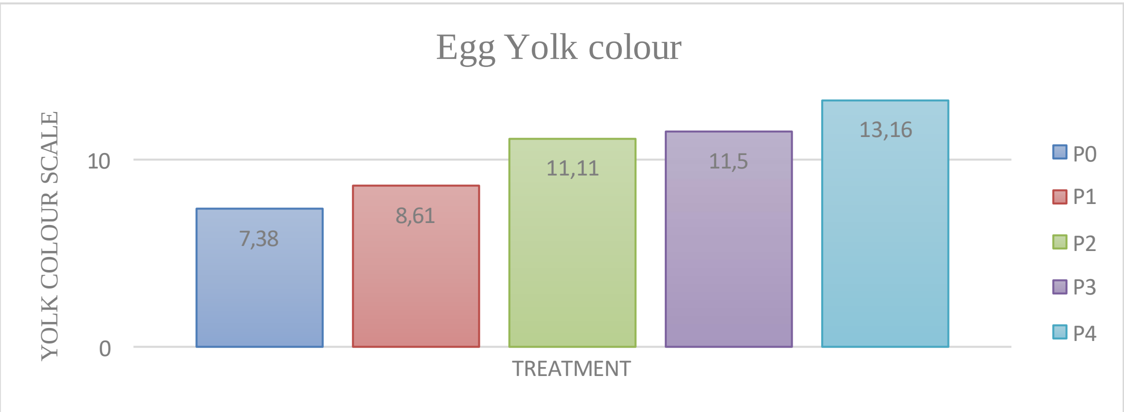

Figure 1. Effect MLM to yolk pigmentation

Description: T0: 0% MLM addition, T2.5: 2.5% MLM addition, T5: 5% MLM addition, T7.5: 7.5% addition of MLM, T10: 10% addition of MLM. Different notations in the same column indicate the results of significant differences (* for P value <0.05).

Figure 2. The differences of yolk pigmentation