RESEARCH ARTICLE

BORNEO SCIENCE
THE JOURNAL OF SCIENCE & TECHNOLOGY

**Journal homepage: https://jurcon.ums.edu.my/ojums/index.php/borneo-science**

# IMPACT OF SORGHUM GRAIN INCLUSION IN PELLET ON FEED INTAKE, GROWTH PERFORMANCE, AND BLOOD METABOLIC PROFILE OF MUSCOVY DUCKS

**Rosesyaqirah Baiduri Abd Razak[1], Mohammad Mijanur Rahman[2*], Nurhanan Abdul Rahman[1], Md Safiul Alam Bhuiyan[2], and Mohamad Asrol Kalam[2]**

[1]Faculty of Agro-Based Industry, Universiti Malaysia Kelantan, Jeli 17600, Kelantan, Malaysia.
[2]Livestock Production Programme, Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Mile 10, Sg. Batang, 90000, Sandakan, Sabah, Malaysia.

**[*]Correspondence:**
mijanur.r@ums.edu.my

**Received:** 8 August 2025
**Revised:** 6 January 2026
**Accepted:** 6 January 2026
**Published online:**
1 March 2026

**Doi:**
10.51200/bsj.v47i1.6693

**Keywords:**
Blood metabolic profile; Feed intake; Growth performance; Muscovy duck; *Sorghum bicolour*

**ABSTRACT**. *The rising cost and limited availability of conventional feed have driven the search for sustainable and economical alternatives. Sorghum grain (Sorghum bicolour), with a nutritive value comparable to maize, is considered a suitable substitute in poultry diets. This study evaluated the effects of sorghum grain inclusion in duck pellets on feed intake, growth performance, and blood profile. Thirty unsexed ducks, approximately 21 days old, were assigned to two groups: one fed sorghum-based pellets (treatment) and the other fed commercial pellets (control). Over six weeks, feed intake, growth, and blood parameters were assessed. Ducks fed the sorghum-enriched pellets showed significantly (p<0.05) better growth, with higher body weight (1298.0 vs. 953.3 g/bird) and daily weight gain (30.9 vs. 22.7 g/day/bird). They also had a lower, though not significant (p>0.05), feed conversion ratio (4.9 vs. 6.9). There were no significant differences and no adverse effects on blood biochemistry profiles. In conclusion, incorporating sorghum grain into duck pellets improves growth performance and positively influences blood profiles.*

## INTRODUCTION

Poultry play a vital role in agriculture and food production, contributing significantly to sustainability. They are efficient converters of feed into meat or eggs and help recycle nutrients through soil, manure, and feed, supporting sustainable farming systems. Compared to ruminants, poultry emit minimal methane, a potent greenhouse gas, making their production relatively climate-friendly (Zisis *et al.*, 2023). This environmentally conscious aspect is enhanced by practices such as reducing fossil fuel use, improving feed production, and using poultry manure as crop fertiliser.

Feed type is a critical factor in sustainable poultry production. Conventional poultry diets primarily rely on grains and pulses, particularly maize and soybeans. However, sustainable agricultural practices like no-till farming, crop rotation, and cover cropping help sequester carbon in the soil. Moreover, innovative feeding strategies, such as using by-products like fruit pulp, cull crops, or insects reared on agricultural waste, enhance sustainability by promoting nutrient recycling (Ababor *et al.*, 2023).

Despite Malaysia's strong self-sufficiency in broiler and egg production, the country remains heavily dependent on imported feed ingredients, especially maize and soybean meal, making the poultry sector vulnerable to global supply disruptions and price fluctuations (Ashraf & Abd. Rahman, 2022; Jamaludin *et al.*, 2023). The recent surge in feed costs, exacerbated by events such as the COVID-19 pandemic, has further challenged the sustainability and profitability of poultry production (Elleby *et al.*, 2020). In response, researchers have turned to cultivating sorghum (*Sorghum bicolour*) domestically as an alternative to maize. Sorghum, a drought-resistant cereal crop in the Poaceae family, is adaptable to warm climates and shows high genetic and phenotypic diversity (Chakrabarty *et al.*, 2022; Kamal *et al.*, 2023). It is well-suited for Malaysia's climate and can be grown on marginal lands (Nazmi *et al.*, 2022). Low-tannin varieties now available reduce anti-nutritional effects and improve digestibility in poultry (Selle & Ravindran, 2007). Nutritionally, sorghum is similar to maize, rich in starch, protein, lipids, and phenolic compounds (Stefoska-Needham *et al.*, 2015). It also has potential uses in functional foods and bioethanol production (Szambelan *et al.*, 2020). This study evaluated the inclusion of sorghum grain in duck pellets and its effects on feed intake, growth performance, and blood biochemistry, offering insights into its viability as a sustainable and cost-effective feed alternative for the poultry industry.

## MATERIALS AND METHODS

### Study Site

The study was conducted at Pondok Al Jaafar in Gua Tempurung, 31600 Gopeng, Perak, Malaysia. The site experiences both wet and dry seasons, with mean temperatures ranging from a minimum of 23 °C to a maximum of 34 °C. The experimental animals used were locally sourced crossbred unsexed Muscovy ducks (*Cairina moschata*), approximately 7 days of age. The ducks were acclimatised to their new environment for 14 days and fed a commercial starter pellet diet appropriate for the early growth stage before the feeding trial began.

### Ration Formulation

The diets were formulated using Winfeed 2.8 software (Table 1). The control diet consisted of commercial feed with maize and soybean meal as its primary ingredients. In the treatment diet, sorghum grain was substituted entirely for maize. All diets were balanced to meet the nutrient requirements of growing ducks (Hakem *et al.*, 2025). Starter and grower pellets contained more crude fibre compared to commercial pellets.

**Table 1.** Composition of experimental diets for ducks.

| Ingredients | Commercial grower pellet$^{+}$ | Starter pellet (%) | Grower pellet (%) |
|---|---|---|---|
| Sorghum grain | - | 43.1 | 45.0 |
| Soybean meal | - | 20.0 | 12.2 |
| Fish meal | - | 6.5 | 4.1 |
| Rice bran | - | 9.0 | 14.0 |
| Palm kernel meal | - | 7.3 | 10.8 |
| Limestone | - | 0.3 | 0.5 |
| Salt | - | 0.3 | 0.5 |
| Palm oil | - | 8.5 | 6.0 |
| Molasses | - | 4.0 | 5.5 |
| Vitamin premix | - | 0.5 | 0.7 |
| Mineral premix | - | 0.5 | 0.7 |
| Nutritive value (%, dry matter basis) | | | |
| Dry matter | 89.20 | 89.80 | 89.92 |
| Crude protein | 18.97 | 21.6 | 17.99 |
| Crude fibre | 5.68 | 8.07 | 8.67 |
| Ether extract | 1.12 | 4.49 | 4.18 |
| Ash | 5.46 | 4.97 | 5.27 |
| Metabolisable energy (kcal/kg)* | 2956 | 2923 | 2767 |

*calculated from secondary data (Yusoff *et al.,* 2005); $^{+}$, not given because of business privacy.

After sorghum grain was procured from a local supplier, it was ground using a hammer mill to achieve a uniform particle size suitable for pellet production. The ground sorghum was then mixed with other ingredients in an industrial mixer to ensure homogeneity, critical for providing balanced nutrition to the ducks. The feed mixture was pelletised using a pelletising machine, forming cylindrical pellets. These pellets were then dried in a dehydrator to reduce their moisture content, thereby enhancing their quality and shelf life. The prepared feed was stored in vacuum-sealed containers to maintain freshness. During pelletising, the temperature was maintained below 70 °C to minimise heat damage to heat-sensitive nutrients such as lysine and vitamins. Drying was carried out at 60 °C until the moisture content reached about 10 – 12%, ensuring nutrient preservation while maintaining pellet durability.

**Experimental Design**

All ducks were evenly distributed into two dietary groups. The control group consisted of 15 ducks (9 males and 6 females), while the treatment group consisted of 15 ducks (9 males and 6 females). Each group was divided into three replicates of five ducks per replicate (3 males and 2 females). The ducks were randomly allocated to the groups and replicates using a simple randomisation method, where each duck was assigned a number and grouped using a random number generator to avoid selection bias. The sample size (n = 30) was selected based on previous similar feeding trials involving Muscovy ducks, which demonstrated that a minimum of 10–15 birds per group provides sufficient statistical power to detect significant differences in growth and blood parameters (Marzoni *et al.*, 2005; Hakem *et al.*, 2025). This number also reflects practical and ethical considerations related to housing space, resource availability, and animal welfare. The trial lasted for six weeks, after which the ducks were slaughtered for further analysis.

The study employed a twice-daily feeding schedule at 8:00 am and 5:00 pm. The birds were fed their experimental diets on an *ad libitum* basis. Water was provided with free access. The control group of ducks was fed a commercial grower pellet diet throughout the study. The treatment group was fed a starter pellet for the first four weeks, followed by a grower pellet for the final two weeks. The feed and water troughs were thoroughly cleaned to prevent contamination.

**Parameters Observed**

Ducks were weighed weekly throughout the trial to monitor growth. Daily feed intake was determined by weighing the daily total feed offered and subtracting the leftover feed (dry matter basis). Daily feed and cumulative intakes were recorded. Temperature and humidity were also documented during the experimental period. Average daily weight gain (ADWG) and feed conversion ratio (FCR) were calculated using Equations 1 and 2.

$$\text{ADWG} = (\text{Total Weight}) / 7 \quad (1)$$

$$\text{FCR} = \frac{\text{Daily feed intake (g)}}{\text{Daily body weight gain (g)}} \quad (2)$$

Blood samples were collected during the slaughtering session at the end of the trial. The blood was immediately sent to Medi-Vance Healthcare, Ipoh, Malaysia, for biochemical analysis. Key parameters assessed included haemoglobin levels, red blood cell count, mean corpuscular haemoglobin, white blood cell (WBC) count (neutrophils, lymphocytes, monocytes, and eosinophils), and platelets. These markers provided insights into the ducks' overall health, immune response, and oxygen-carrying capacity. Reference ranges for duck haematological parameters, including WBCs (typically 10–30 × $10^9$/L), were used to evaluate abnormalities in the results (Olayemi *et al.*, 2003).

## Statistical Analysis

Data were analysed using one-way ANOVA with SPSS statistical software (version 23.0). Post hoc comparisons between treatment means were performed, and differences were considered statistically significant at $p < 0.05$. Results are reported as mean ± standard deviation.

## RESULTS AND DISCUSSION

### Feed Intake

The weekly feed intake of ducks fed experimental diets varied over the six weeks (Figure 1). In Week 1, the control group consumed significantly ($p<0.05$) more feed (813.3 g/duck) than the treatment group (724.7 g/duck). A similar trend was observed in Week 2, where the control group (838.3 g/duck) again consumed more than the treatment group (795.7 g/duck). In Week 3, feed intake remained significantly higher in the control group (1033 g/duck) than in the treatment group (982 g/duck). However, in Week 4, the treatment group (1049.3 g/duck) surpassed ($p<0.05$) the control group (1008 g/duck). In Weeks 5 and 6, intake differences were not statistically significant ($p>0.05$), with the treatment group slightly ahead. Overall, average feed intake across the six weeks was not significantly affected by the dietary treatment ($p>0.05$), indicating that inclusion of the experimental diet did not adversely affect voluntary feed intake in ducks. On average, the control group consumed 958.4 g/duck, while the treatment group consumed 937.6 g/duck, with no significant difference.

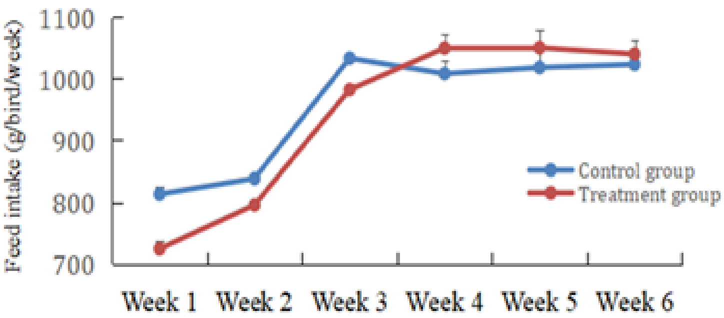


**Figure 1.** Weekly feed intake (g/bird/week) by ducks during the experimental period.

These results indicate notable variations in feed intake, particularly during the initial weeks. The higher early intake observed in the control group may be related to greater palatability and a more familiar nutrient profile, whereas the experimental diet may have initially reduced acceptance due to differences in flavour, texture, or nutrient composition, such as fibre and energy density. As the trial progressed, the treatment group gradually adapted and achieved comparable intake levels, suggesting improved palatability and physiological adjustment to the diet. This pattern is consistent with Arroyo *et al.* (2016), who highlighted the importance of early digestive and behavioural adaptation when novel feed ingredients are introduced. However, physical feed characteristics such as pellet durability and stability, which can further influence palatability and intake, were not evaluated and should be considered in future research.

### Growth Performance

The growth performance data are presented in Table 2. Initial body weights were comparable between groups (control: 346.7 g/duck; treatment: 345.4 g/duck; $p>0.05$). This indicates a uniform starting condition across treatments. By Week 6, ducks fed the treatment diet achieved a significantly ($p<0.05$) higher final body weight (1643.3 g/duck) than those fed the control diet (1300.0 g/duck). Total weight gain and average daily gain were numerically higher in the treatment group (1298.0 g/duck and 30.9 g/day, respectively) than in the control group (953.3 g/duck and 22.7 g/day); however, these differences were not statistically significant ($p>0.05$). Feed conversion ratio (FCR) was numerically lower in the treatment group (4.9) compared with the control group (6.9), but the difference was not statistically significant (p = 0.144), indicating that the treatment diet did not significantly alter feed efficiency under the present experimental conditions.

**Table 2.** Growth performance of ducks fed experimental diets.

| Parameter | Control group | Treatment group | *p* - value |
|---|---|---|---|
| Initial body weight, g/bird | 346.70 ± 88.51 | 345.40 ± 56.18 | 0.984 |
| Final body weight, g/bird | 1300.00 ± 166.67 | 1643.30 ± 128.97 | 0.048 |
| Total body weight gain, g/bird | 953.30 ± 236.39 | 1298.00 ± 82.83 | 0.076 |
| Daily body weight gain, g/bird | 22.70 ± 5.63 | 30.90 ± 1.97 | 0.076 |
| Feed conversion ratio | 6.90 ± 1.95 | 4.90 ± 0.32 | 0.144 |

**Weekly Body Weight**

Body weight increased steadily in both groups over six weeks (Figure 2). Week 1 weights were nearly identical. In Week 2, the treatment group (589.4 g/bird) tended to exceed the control (361.2 g/bird), but it was not found to be significantly (p>0.05) different. In Week 3, the control group recorded a slightly higher weight (587.1 g/bird). From Week 4 onwards, the treatment group consistently outperformed, culminating in a significantly (p=0.048) higher final weight in Week 6. These results align with overall growth trends, suggesting that ducks fed the treatment diet adapted over time and improved nutrient utilisation, as supported by Arroyo *et al.* (2016).

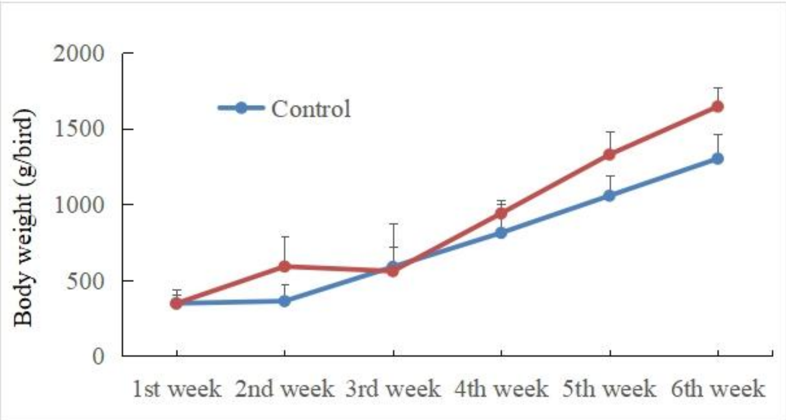


**Figure 2.** Weekly body weight of ducks fed experimental diets.

**Blood Metabolic Profile**

The blood metabolic profile (Table 3) revealed no statistically significant (p>0.05) differences between the control and treatment groups. Overall, the results indicate that the treatment diet did not alter blood metabolic profiles and did not exert any adverse physiological effects on the ducks. Although the treatment group showed slightly higher haemoglobin levels, red and white blood cell counts, neutrophils, and lymphocytes, these were not significant (p>0.05). Both groups had WBC counts above the reference range reported by Olayemi *et al.* (2003), which could reflect breed-specific traits, environmental factors, or subclinical responses unrelated to diet. Platelet counts were lower in the treatment group, though not significantly. These findings should be interpreted cautiously, as trends in immune-related values suggest a physiological response, but no definitive conclusions can be drawn. Despite minor numerical variations in some haematological parameters, all measured values remained within physiologically acceptable limits, indicating normal health status. Jerabek *et al.* (2018) similarly reported that dietary changes did not always impact blood biochemistry significantly. The elevated WBC count in the treatment group may indicate subclinical infection, individual variability, or breed-related differences. The high standard deviation in platelet counts, particularly in the control group, may reflect sampling variability or outliers, warranting further investigation. Collectively, these findings confirm that partial replacement of maize with sorghum did not compromise haematological health. This study helps fill a knowledge gap by evaluating sorghum as a maize substitute in duck diets, an area less explored compared to chicken studies. Given ducks' unique digestive systems, such evaluations are essential. Based on the present results, inclusion of sorghum at 43–45% can be considered safe, supporting normal physiological function, growth performance, and feed intake.

**Table 3.** Blood metabolic profile of ducks fed experimental diets.

| Parameter | Control Group | Treatment Group | p - value |
|---|---|---|---|
| Haemoglobin (g/dL) | 10.40 ± 0.81 | 11.20 ± 0.95 | 0.314 |
| Red blood cell ($\times 10^{12}$/L) | 2.20 ± 0.12 | 2.30 ± 0.20 | 0.521 |
| Mean corpuscular haemoglobin (pg) | 49.30 ± 1.53 | 49.70 ± 1.53 | 0.802 |
| White cell count ($\times 10^{9}$/L) | 69.10 ± 63.57 | 111.40 ± 49.59 | 0.415 |
| Neutrophils ($\times 10^{9}$/L) | 41.90 ± 39.05 | 68.10 ± 28.35 | 0.400 |
| Lymphocytes ($\times 10^{9}$/L) | 22.60 ± 19.89 | 35.80 ± 17.32 | 0.435 |
| Monocytes ($\times 10^{9}$/L) | 3.80 ± 4.10 | 6.80 ± 3.98 | 0.421 |
| Eosinophils ($\times 10^{9}$/L) | 0.80 ± 0.56 | 0.70 ± 0.74 | 0.842 |
| Platelets ($\times 10^{9}$/L) | 131.30 ± 175.62 | 33.30 ± 14.36 | 0.390 |

## CONCLUSION

This study highlighted the significant positive effects of incorporating sorghum grain into duck feed pellets, improving growth performance, feed efficiency, and overall health. Sorghum grain proved to be a suitable ingredient for duck diets without compromising nutritional needs. However, further research is needed to determine optimal sorghum grain levels across different duck breeds, ages, and production stages. Future studies should explore long-term impacts, nutrient digestibility, and additional health indicators to enhance our understanding of sorghum grain's role in sustainable duck production systems.

## REFERENCES

Ababor, S., Tamiru, M., Alkhtib, A., Wamatu, J., Kuyu, C.G., Teka, T.A., Terefe, L.A. & Burton, E. 2023. The use of biologically converted agricultural byproducts in chicken nutrition. *Sustainability*, 15(19): 14562.

Arroyo, J., Dubois, J.P., Lavigne, F., Brachet, M. & Fortun-Lamothe, L. 2016. Effects of replacing corn with sorghum on the performance of overfed mule ducks. *Poultry Science*, 95(6): 1304–1311.

Ashraf, A.M. & Abd. Rahman, F.B. 2022. Hazards in poultry feed production: an appraisal fromthe halal perspective. *Journal of Fatwa Management and Research*, 27(2-SE).

Chakrabarty, S., Mufumbo, R., Windpassinger, S., Jordan, D., Mace, E., Snowdon, R.J. & Hathorn, A. 2022. Genetic and genomic diversity in the sorghum gene bank collection of Uganda. *BMC Plant Biology,* 22: 378.

Elleby, C., Domínguez, I.P., Adenauer, M. & Genovese, G. 2020. Impacts of the COVID-19 pandemic on the global agricultural markets. *Environmental and Resource Economics,* 76: 1067–1079.

Hakem, M.Z.A., Qi, K.S., Rahman, M.M., Kari, Z.A. & Len, C.S.C. 2025. Effect of *Asystasia gangetica* inclusion in the diet on the feed intake, growth performance, and meat quality of Muscovy ducks. *Tropical Animal Health and Production*, 57: 85.

Jamaludin, M.H., Marsal, C.J., Chowdhury, A.J.K., Anwari, A.S., Razimi, M.S.A., Harith, Z.T., Redwan, R.M., Abdullah, Z.A.K, & Amiruddin, A.Z. 2023. Egg and broiler supply in Malaysia: Issues, challenges and recommendations. *Halalsphere*, 3(1): 11–19.

Jerabek, M., Suchy, P., Strakova, E., Kudelkova, L., Simek, V., Jakesova, P., Machacek, M. & Zapletal, D. 2018. Selected blood biochemical indicators of Cherry Valley ducks undergoing fattening in relation to their diet and sex. *Veterinarni Medicina*, 63(9): 420–432.

Kamal, N.M., Gorafi, Y.S.A., Tomemori, H., Kim, J.S., Elhadi, G.M.I. & Tsujimoto, H. 2023. Genetic variation for grain nutritional profile and yield potential in sorghum and the possibility of selection for drought tolerance under irrigated conditions. *BMC Genomics*, 24(1): 515.

Marzoni, M., Castillo, A. & Romboli, I. 2005. Performances of growing Muscovy ducks fed on diets supplemented with Quebracho tannin powder. XVII th European Symposium on the Quality of Poultry Meat, Doorwerth, The Netherlands, 23-26 May 2005, pp. 336–341.

Nazmi, M.S., Dardak, R.A., Nik Omar, N.R. & Ghani, M.N.O. 2022. Sorghum as a new source of animal feed in Malaysia. International publication by FFTC-AP. https://ap.fftc.org.tw/article/3213

Olayemi, F., Oyewale, J., Rahman, S. & Omolewa, O. 2003. Comparative assessment of the white blood cell values, plasma volume and blood volume in the young and adult Nigerian duck (*Anas platyrhynchos*). *Veterinarski Arhiv,* 73(5): 271–276.

Selle, P.H. & Ravindran, V. 2007. Microbial phytase in poultry nutrition. *Animal Feed Science and Technology*, 135(1–2): 1–41.

Stefoska-Needham, A., Beck, E.J., Johnson, S.K. & Tapsell, L.C. 2015. Sorghum: An underutilized cereal whole grain with the potential to assist in the prevention of chronic disease. *Food Reviews International*, 31(4): 401–437.

Szambelan, K., Nowak, J., Szwengiel A. & Jeleń, H. 2020. A water-saving fermentation process for sorghum grain: the effect of re-using stillage liquid part on ethanol efficiency and volatile compounds. *Journal of Cleaner Production*, 265: 121830.

Yusoff, H.M.S., Sharif, S. & Noormah, M.A. 2005. Nutrient composition of Malaysian feed materials and guides to feeding of cattle and goats. 2nd edition, Department of Veterinary Services, Ministry of Agriculture and AgroBased Industry Malaysia. Available online: http://www.dvs.gov.my/dvs/resources/auto%20download%20images/560a42a080bb4.pdf

Zisis, F., Giamouri, E., Mitsiopoulou, C., Christodoulou, C., Kamilaris, C., Mavrommatis, A., Pappas, A.C. & Tsiplakou, E. 2023. An overview of poultry greenhouse gas emissions in the Mediterranean area. *Sustainability*, 15(3): 1941.