

Enhancing Japanese quail growth performance and egg quality through effective microorganism water supplementation in diet

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Abstract: Effective Microorganisms (EM) are probiotic mixtures of beneficial bacteria that improve gut health by reducing harmful pathogens to improve growth performance. EM support overall health and egg production in avians by balancing intestinal microflora. This study investigated the impact of EM supplementation via drinking solution on the growth performance and egg quality of quails. A total of 64 quails were divided into four treatment groups, with each group receiving a different concentration of EM in their drinking water. Growth performance, such as feed intake, body weight gain, and feed conversion ratio (FCR), were monitored weekly for seven weeks. Egg quality parameters, including egg yolk color, shell thickness, albumen height, and Haugh unit, were evaluated during the final week of the study. The results demonstrated that quails supplemented with EM exhibited improved growth performance; with a significant reduction ($p < 0.05$) in FCR and enhanced weight gain compared to the control group. In terms of egg quality, EM supplementation led to improve the yolk pigmentation and albumen height, resulting in higher Haugh unit scores. Shell thickness was also positively influenced ($p < 0.05$) by the EM concentrations. The findings indicate that EM supplementation in quail diets can enhance both growth performance and egg quality, making it a profitable strategy for sustainable poultry farming. Future studies could explore the long-term effects of EM and its influence on other physiological and reproductive traits.

Keywords: egg quality, effective microorganism, feed conversion ratio, growth performance, quail feed supplementation

1. Introduction

The demand for poultry products has been rising due to population growth and changing dietary habits. While chickens dominate the poultry industry, quails (*Coturnix coturnix japonica*) are gaining popularity for their rapid growth, early maturity, high egg production, and resilience to diseases (Cheong et al., 2016). Quails require less space, consume less feed, and produce nutrient-rich meat and eggs, making them an attractive option for both small-scale and commercial farmers (Jumadin et al., 2022). However, quail farming remains underutilized due to limited research and farmer awareness (Wong et al., 2025). Expanding research on quail farming and nutritional strategies is essential to optimize production efficiency and enhance food security and productivity (Juan, 2026).

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One promising approach to improving feed efficiency, growth performance, and egg quality is the supplementation of Effective Microorganisms (EM) in poultry diets. EM consists of beneficial microorganisms such as lactic acid bacteria, yeast, and photosynthetic bacteria that enhance digestion, improve nutrient absorption, and support immune function (Gnanadesigan et al., 2014). These microorganisms help maintain a balanced gut microbiota, suppress harmful bacteria, and promote overall gut health, which is crucial for efficient feed utilization and improved productivity (Gesek et al., 2018; Xiang et al., 2019)

Studies have demonstrated that EM supplementation positively impacts poultry performance, including weight gain, feed conversion ratio (FCR), and egg production (Biswas et al., 2015). Utami & Akbar (2025) has utilised EM in their *Leucaena leucocephala* leaf meal for laying quail. The findings found that EM assisted the leaf fermentation process and improved egg productivity with significantly better egg yolk color.

Probiotics in poultry diets enhance intestinal morphology, increasing villus height and crypt depth, which leads to improved nutrient absorption (Gesek et al., 2018; Nur Azri et al., 2018; Ahmad et al., 2022). Additionally, probiotics have been reported to improve egg quality parameters such as yolk pigmentation, albumen height, shell thickness, and Haugh unit scores. These preferences are both increases market demand as well as consumer preference (Neijat et al., 2020; Atsbeha & Hailu, 2021).

Quail eggs are valued for their rich nutritional profile, containing high levels of proteins, essential amino acids, vitamins, and minerals (Shalome et al., 2021). They are associated with various health benefits, including improved immune function and reduced risk of chronic diseases due to their antioxidant properties. The internal and external qualities of poultry eggs, such as yolk color, shell thickness, albumen height, and Haugh unit, are key determinants of egg quality, and these parameters can be influenced by dietary modifications, including probiotics like EM (Atsbeha & Hailu, 2021; Yitbarek, 2023). Both quantity and quality of quail eggs relied on gut health and nutrient utilization ability through EM supplementation.

However, more studies are required to examine the effects of EM supplementation on quails in order to establish the effective EM concentration towards growth performance and egg quality. This study aims to investigate the effects of EM supplementation on the growth performance and egg quality of quails. Specifically, it would evaluate the impact of different EM concentrations in drinking water on key performance indicators; including feed intake, body weight gain (BWG), and FCR. Additionally, egg quality parameters such as yolk pigmentation, shell thickness, albumen height, and Haugh unit was assessed.

The findings would contribute to sustainable poultry farming practices and provide recommendations for optimizing quail diets. The results of this study could benefit quail farmers and poultry nutritionists seeking to enhance production efficiency and product quality. If proven effective, EM supplementation could serve as a natural and cost-effective alternative to conventional growth promoters, reducing reliance on antibiotics and mitigating antibiotic resistance in poultry farming. Improved growth performance and egg quality in quails could also enhance the commercial viability of quail farming, encouraging wider adoption and diversification in the poultry industry. While probiotics have been extensively studied in poultry, research on quails remains exploratory. This study seeks to bridge this knowledge gap by evaluating the effects of EM on quail production, contributing valuable insights for improving quail farming practices and promoting sustainable poultry production.

2. Materials and Methods

2.1 Study area

This research was conducted in the Poultry Research Facility at the Faculty of Sustainable Agriculture (FSA), Universiti Malaysia Sabah, Sandakan, Sabah. The quails were kept in a controlled setting in separate cages for the duration of the study. Each cage had sufficient space,

feeders, and nipple drinkers to ensure easy access to food and water. All cages and equipment were thoroughly cleaned and disinfected before the quails were introduced. The environment was maintained through regular waste removal and routine upkeep to ensure optimal conditions throughout the study.

2.2 Experimental animal and dietary treatment

A total of 64-day old quail chicks were bought from Department of Veterinary. The experimental groups were including one control group and three treatment groups to study growth performance and egg quality using commercial EM supplementation (EM4, BH Farm) in quail diets. The treatment groups received the baseline diet with 0.5%, 1.0%, and 1.5% of EM solution supplementation via filtered water, whereas the control group would receive the basal diet without any EM supplementation as in Table 1. The quails were randomly allocated to these groups to reduce bias, and each group was closely observed to ensure similar conditions throughout all groups.

Table 1. Experimental cages and animal managements.

Treatment	EM supplementation level (%)	Number of quails	Duration (weeks)
Control (T1)	0	16	8
Treatment 1 (T2)	0.5	16	8
Treatment 2 (T3)	1.0	16	8
Treatment 3 (T4)	1.5	16	8

2.3 Experimental design

This study used a Completely Randomized Design (CRD), this study aims to evaluate the impact of varying levels of EM supplementation on both the quality of quail eggs and their growth performance. Basal diet was prepared and fed to quails for a total of eight weeks, with the diet adjusted based on the age of the birds as recommended by National Research Council (1994). The diet was divided into two phases; a starter diet for the first five weeks, followed by a grower diet for the remaining three weeks. Each treatment consisted of four replicates, with each cage received 150 g of feed. The unsexed quails were monitored regularly to ensure uniform feed intake and growth. The starter diet was formulated to meet the nutritional requirements of young quails, while the grower diet was designed to support the birds' growth during the later stages of development. The dietary formulations for both phases were based on established recommendations for quail nutrition. The EM supplementation was prepared and incorporated into the quails' drinking water according to the experimental design (Utami & Akbar, 2025). A commercial EM product was diluted with water to achieve the required concentrations of 0%, 0.5%, 1.0%, and 1.5%. For each treatment group, 600 mL of water was provided in week 2, 1200 mL from week 3 to 5, and 2400 mL from week 6 to 8. The respective volume of EM product was added using a syringe to each water volume, ensuring the correct concentration for each treatment group. The EM solutions were offered *ad libitum*, and their concentrations were routinely monitored (morning and afternoon) daily and adjusted as necessary to maintain consistency throughout the study, accounting for any changes in ambient conditions or water consumption rates (Rahman et al., 2019).

2.4 Variables and Sampling

Quail's body weight gain was calculated as the mean weight recorded during treatment period for growth performance. The amount of feed given to each quail group was measured regularly, ensuring reliable tracking of consumption. Any leftover feed was gathered and weighed daily. The daily feed intake for each quail group was calculated by deducting the weight of the leftover

feed from the original amount given throughout the experimental period. The formulation to determine Feed Conversion Ratio (FCR) as shown in Equation 1 (Varkoohi et al., 2010) is the proportion of feed consumed over a specified period relative to the weight of eggs produced during that period:

$$\text{FCR} = \frac{\text{Total feed consumed}}{\text{Total weight gain}} \quad \text{Equation 1}$$

Parameters such as egg weight were analysed and measured analytical scale with 0.01g deviation. Measurements were conducted in a controlled environment to minimize external factors affecting accuracy. The eggshell thickness was measured using an eggshell thickness gauge (Models 3001, DIG) as done by Zhu et al. (2022). The thickness was recorded in micrometres, and the average of the three measurements was calculated to represent the overall eggshell thickness for each egg. The tester probe (ORKA Digital Haugh Tester) was placed at the thickest part of the albumen to measure the albumen height, and at the thickest part of the yolk to measure the yolk thickness. (Renukadevi et al., 2018). The Haugh unit (HU) was calculated using the Equation 2 introduced by Raymond Haugh in (Haugh, 1937).

$$\text{HU} = 100 \log (H + 7.57 - 1.7W^{0.37}) \quad \text{Equation 2}$$

Egg yolk color was measured manually using the Roche Yolk Colour Fan (RYCF). The color of the yolk was visually matched to the closest shade on the RYCF, and the corresponding number was recorded as the yolk color score. (Sünder et al., 2022). For pH measurement, the yolk and white (albumen) of the egg were prepared by separating egg yolk and the white before placed into Falcon tube. A pH meter (Eutech Instruments, pH 2700, USA) was used to determine the mean pH of the egg white and yolk. (Aygün & Olgun, 2019).

2.5 Statistical analysis

The data were analysed using one-way analysis of variance (ANOVA) with Minitab 16.2.3 (2010). Post-hoc comparisons were performed using Tukey's test at a 95% confidence level ($p < 0.05$) to determine significant differences between means.

3. Results and Discussion

The purpose of this study was to evaluate the addition Effective Microorganisms (EM) to quail diets at different concentrations (0%, 0.5%, 1.0%, and 1.5%) affected egg quality, feed efficiency, and growth performance. The findings are provided in terms of their effects on important parameters such as growth performance, feed conversion ratio (FCR), feed and water intake, and egg internal and external quality.

3.1 Growth performance

Growth performance measures the total efficacy of dietary treatments in promoting body weight gain and health in quails. The mean body weight increased steadily across all treatments (T1, T2, T3, and T4) from week two to week eight. At week eight, T4 (1.5% EM) had the highest mean body weight (248.44 g), followed by T3 (240.81 g), T2 (239.94 g), and T1 (219.88 g). However, statistical analysis showed no significant differences in mean body weight between the treatments for weeks two to seven ($p > 0.05$).

At week eight, T4 was significantly different from T1 ($p < 0.05$), while T3 and T2 were statistically comparable to both T4 and T1. This indicates that EM supplementation did not significantly affect body weight in the early weeks but showed a trend for higher body weight at higher EM levels (1.5%) by the end of the study as shown in Figure 1.

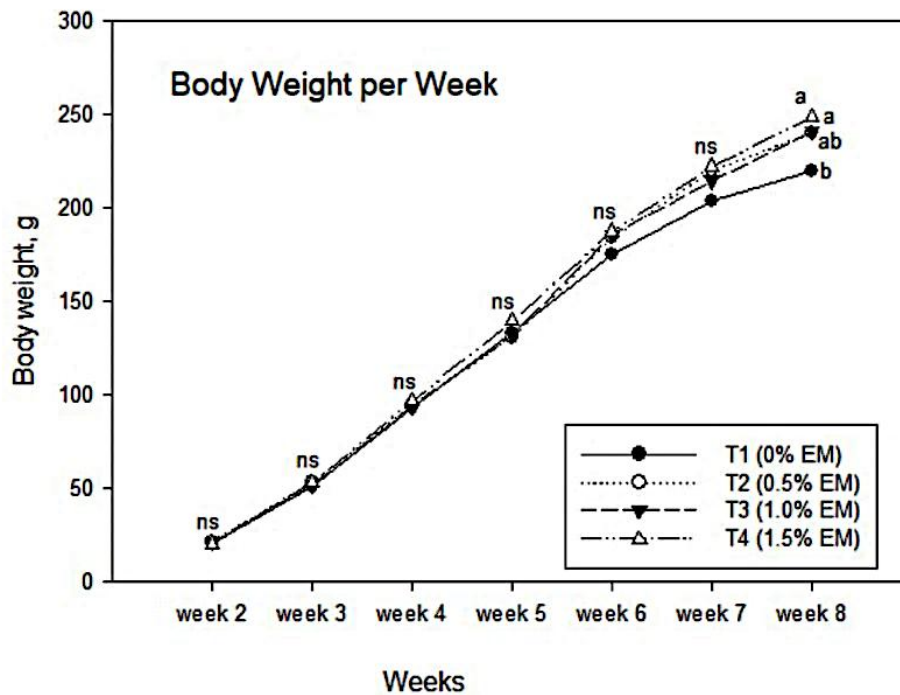


Figure 1. Quail's weekly body weight gain (BWG).

EM supplementation considerably improved quail growth performance, with T4 (1.5% EM) resulting in the highest body weight gain by week 8. This is consistent with the findings of Ahmad et al. (2022), who showed that probiotics improve gut health and nutrient absorption, especially under stressful environmental conditions, by increasing villus height and crypt depth. These morphological enhancements are directly proportional to the increased surface area available for nutrient absorption, resulting in optimal growth rates. Furthermore, probiotics such as *Bacillus subtilis* and *Lactobacillus spp.* have been proven to alter the gut microbiota, increasing the number of beneficial bacteria while reducing pathogenic germs (Aziz Mousavi et al., 2018; Deng et al., 2020). This microbial balance enhances the intestinal environment, enabling more efficient digestion and nutritional utilisation. Probiotics' production of short-chain fatty acids (SCFAs) helps to increased energy metabolism and feed efficiency, resulting in higher growth rates.

Additionally, while T4 showed the greatest growth, T2 (0.5% EM) had the best feed conversion ratio (FCR), implying that mild EM supplementation will not bring extra benefits, thus may be more cost-effective for farmers looking to balance growth and efficiency. Aziz Mousavi et al. (2018) reported similar findings, emphasising the economic benefits of adjusting probiotic dosage to meet specific production goals. These findings highlight the potential of EM as an antibiotic alternative, hence promoting sustainable poultry farming practices.

3.2 Feed conversion ratio

Table 2 showed the effects of EM supplementation on feed and water intake, as well as FCR was demonstrated on how even low concentrations can improve resource utilisation while preserving productivity. Feed intake observed to be consistent across treatments, showing no significant differences ($p > 0.05$). Water intake tended to decrease slightly with higher EM concentrations, which might indicate improved nutrient utilization. The FCR pattern was similar to Utami & Akbar (2025) revealed no significant differences across the experimental groups. This is likely because of the basal diet met the standard nutritional requirements for

laying quail. Abou-Kassem et al. (2020) reported no significant difference ($p > 0.05$) observed in quails fed with *Bacillus toyonensis* and *Bifidobacterium bifidum*. However, FCR was recorded differently based on experimental period. In this study, FCR was lowest in T2 (0.5% EM) at 3.36 ± 0.87 , suggesting that this treatment was the most potential in converting feed into body mass or egg production and cost-effective supplementation level.

Table 2. Feed and water intake with feed conversion ratio (FCR) by different treatments.

Parameters	T1 (0% EM)	T2 (0.5% EM)	T3 (1.0% EM)	T4 (1.5% EM)
Feed intake (g)	122.8a \pm 8.78	107.9 a \pm 6.60	119.3 a \pm 6.41	122.8 a \pm 7.91
Water intake (mL/bird)	435.9 a \pm 79.2	414.1 a \pm 64.4	376.5 a \pm 57.9	399.4 a \pm 71.3
FCR	3.80 a \pm 1.13	3.36 a \pm 0.87	3.58 a \pm 0.75	3.53 a \pm 0.62

Note: Values are presented as mean \pm standard deviation. Same letter denotes mean values are not significantly different $p > 0.05$ at the same row.

Supplementing EM considerably increased the feed conversion ratio (FCR) in quails, with T2 (0.5% EM) having the lowest FCR (3.36 ± 0.87). This suggests that even small amounts of EM can improve feed efficiency by optimising feed conversion into body mass or egg production. Consistent with these findings, Aziz Mousavi et al. (2018) found that probiotics such *Bacillus subtilis* increase FCR by altering gut microbiota, lowering pathogenic bacteria, and promoting beneficial microbe development. These modifications lead to enhanced nutrition uptake and utilisation. The observed FCR benefits can be related to probiotics' ability to increase the synthesis of digestive enzymes such amylase and lipase, which aid in the breakdown of feed into absorbable nutrients (Deng et al., 2020). Furthermore, probiotics generate short-chain fatty acids (SCFAs), which improve energy metabolism and nutrition absorption (Aziz Mousavi et al., 2018). The small decrease in water intake seen at higher EM concentrations could possibly reflect greater feed digestibility and less need for additional water to process nutrients.

The decrease in feed intake observed in Treatment 2 (T2), which was positioned closer to the light source, can be attributed to temperature stress. Extreme temperatures are known to negatively impact feed consumption, as highlighted by Nawab et al. (2018). Despite this reduction in feed intake, the growth trend from Treatment 1 (T1) to Treatment 4 (T4) still showed an increase. This suggests that the beneficial effects of EM supplementation on nutrient utilization were able to offset the negative impact of the reduced feed intake in T2.

Interestingly, although T2 exhibited the best feed conversion ratio (FCR), this can be explained by the fact that EM supplementation may enhance the efficiency of feed usage, leading to better growth even with less feed consumed. This observation aligns with the findings of Jha et al., (2020), which emphasize the positive effects of using probiotics, such as EM, at moderate doses to improve growth performance and feed utilization in poultry farming. Therefore, despite the temperature-related decrease in feed intake, the superior FCR in T2 demonstrates the significant role of EM supplementation in enhancing the efficiency of nutrient absorption and utilization.

3.3 Egg internal and external quality

The addition of Effective Microorganisms (EM) at various concentrations resulted in considerable improvements in key egg quality indices, including yolk colour, albumen weight, and Haugh unit as shown in Table 3. The data show that EM supplementation had no significant effect ($p > 0.05$) on the pH of either yolk or albumen, as all treatments (T1-T4) had similar values. Egg weight increased with higher EM concentrations, with T4 (1.5% EM) producing the heaviest eggs (10.05 ± 0.28). Higher EM concentrations led to a small increase in yolk

colour intensity, with T4 (1.5% EM) producing the brightest colour (11.67 ± 0.18). Higher concentrations, specifically T4 (1.5% EM), resulted in a considerable increase in yolk colour intensity (11.67 ± 0.18). These findings are consistent with research demonstrating probiotics' potential to increase carotenoid metabolism and bioavailability, resulting in more excellent yolk pigmentation (Mazanko et al., 2018; Abd El-Hack et al., 2020). Vibrant yolk colour is highly desired in the market because it increases consumer attractiveness and perception of egg quality. This indicates that EM may have a good influence on yolk colour, potentially improving its physical and nutritional value.

Table 3. Effects of different EM percentage supplementation on quail internal and external egg quality.

Parameters	T1 (0% EM)	T2 (0.5% EM)	T3 (1.0% EM)	T4 (1.5% EM)
pH (Yolk)	6.32a \pm 0.04	6.36a \pm 0.03	5.76a \pm 0.008	6.28a \pm 0.039
pH (Albumin)	9.57a \pm 0.03	9.58a \pm 0.03	9.61a \pm 0.008	9.62a \pm 0.014
Yolk Colour	10.83a \pm 0.29	11.17a \pm 0.38	11.33a \pm 0.37	11.67a \pm 0.18
Egg weight (g)	9.02a \pm 0.33	9.46a \pm 0.29	9.52a \pm 0.18	10.05a \pm 0.28
Albumen height (mm)	4.65b \pm 0.27	4.66b \pm 0.22	4.99b \pm 0.25	6.06a \pm 0.20
Haugh unit	92.10b \pm 1.50	91.92b \pm 1.09	93.52b \pm 1.31	98.32a \pm 0.88
Yolk height (mm)	8.97b \pm 0.42	9.32b \pm 0.23	9.71ab \pm 0.39	10.90a \pm 0.29
Egg shell thickness (mm)	0.17b \pm 0.01	0.21ab \pm 0.01	0.22a \pm 0.01	0.21ab \pm 0.01

Note: Values are presented as mean \pm standard deviation. Same letter denotes mean values are not significantly different $p > 0.05$ at the same row.

Higher albumen quality (98.32 ± 0.88) in T4 suggests that EM supplementation improves egg freshness and structural integrity. Similar findings were reported by Neijat et al., (2020) and Utami & Akbar (2025), probiotics specifically *Bacillus subtilis* and *Lactobacillus spp.*, improve nutrient absorption, resulting in higher albumen height and quality. Albumen weight and Haugh unit also improved significantly ($p < 0.05$), indicating better egg freshness and albumen quality, with T4 again outperforming other treatments. Yolk height showed a similar trend, with T4 having the highest value (10.90 ± 0.29), suggesting enhanced yolk structure.

The processes underlying this improvement are most likely related to probiotics' ability to promote nitrogen absorption and protein synthesis, both of which are required for albumen formation (Applegate et al., 2010). These findings underline the importance of EM supplementation in enhancing several aspects of egg quality, making it a valuable tool for improving egg production efficiency and satisfying market needs. Enhanced yolk color, albumen height, and shell strength contribute to higher-quality eggs, which are preferred by customers and function better in transport and storage.

The quality features of eggs, such as egg weight, yolk height, and shell thickness, were positively affected by EM supplementation. T4 (1.5% EM) produced the largest eggs (10.05 ± 0.28 g) and thickest yolks (10.90 ± 0.29 mm). These data imply that EM improves protein and nutrition deposition in eggs, resulting in larger and more structurally stable eggs. Probiotics have been proven in studies to improve protein synthesis and nutrition retention, resulting in higher egg weight and yolk height (Siadati et al., 2018; Neijat et al., 2020).

The improvement in shell thickness at T3 (1.0% EM) highlights the role of probiotics in optimizing calcium metabolism for eggshell development. Probiotics like *Lactobacillus spp.* and *Bacillus subtilis* enhance calcium retention, strengthening the shell and reducing breakage rates, which is beneficial for transportation and storage (Duskaev et al., 2020). However, the modest decrease in shell thickness at T4 (1.5% EM) suggests that excessively high EM

concentrations may not be as effective for shell strength. Shell thickness was highest in T3 (1.0% EM), indicating this concentration might optimize shell strength. However, the decrease in shell thickness at T4 (1.5% EM) indicates that too high EM concentrations may affect calcium metabolism.

This result is consistent with previous research demonstrating that excessive probiotic administration might sometimes result in reduced returns in specific metrics (Xiang et al., 2019). The beneficial impacts on egg weight, yolk height, and shell strength shown in this study show that EM could improve both the interior and exterior properties of eggs. These enhancements lead to increased market value and consumer pleasure, making EM a promising addition for poultry husbandry.

4. Conclusion

Based on the findings of this study, Effective Microorganism (EM) supplementation does not improve FCR but significantly improved growth performance at the end of 8th week compared to control group. We could observe EM supplementation positively influenced egg quality by enhancing yolk pigmentation, albumen height, and Haugh unit scores, as well as shell thickness. Future studies should need separating sex among treatments, increase the number of animals and replications. Exploring the application of EM in other poultry species, such as ducks and chickens, could further validate its effectiveness across different farming systems.

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