Rahmad Susilowarno et al./Animal Production. 28 (2): 108-116, 2026
Accredited by Kemenristek Dikti No 32a/E/KPT/2017. ISSN 1411-2027

Evaluation of Drinking Water Quality in Relation to Body Weight, Feed Efficiency, and Health of Broilers: A Case Study

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Abstract. This study aimed to evaluate the effect of drinking water quality improvement on broiler chicken performance at CV Dua Warna Perkasa. The research employed a comparative observational study design with a pre-post intervention approach, utilizing data collected from three commercial farms before and after the implementation of a comprehensive water quality improvement program. Parameters observed included mortality rate, average body weight (ABW), Feed Conversion Ratio (FCR), Feed Efficiency (FE), and Performance Index (IP). Water quality was assessed through microbiological analysis of samples collected from the source, storage tank, and nipple points, compared against SNI 6488:2019 and Cobb-Vantress 2020 standards. Data were analyzed using descriptive statistics, an independent t-test, and Spearman's correlation. The results showed significant improvements ($p < 0.001$) in all performance parameters after water quality treatment. Mortality rates decreased from 12.00% to 3.77% in Dendi Farm, 10.61% to 3.49% in Endin Farm, and 13.65% to 3.58% in Noh B Farm. Average body weight (ABW) increased significantly in all farms, while FCR improved from an average of 1.731 to 1.496. The Performance Index showed remarkable improvement from an average of 301 to 449, with Cohen's d effect size of 9.42 (very large). Correlation analysis revealed a very strong relationship between water quality and production performance (Spearman's rho = 0.836-0.867; $p < 0.05$). The study concludes that water quality management is a critical factor in broiler production efficiency and health maintenance, with significant implications for farm profitability through improved feed efficiency and reduced mortality.

Keywords: Broiler, water quality, performance, feed efficiency, mortality

Abstrak. Penelitian ini bertujuan untuk mengevaluasi pengaruh peningkatan kualitas air minum terhadap performa ayam broiler di CV Dua Warna Perkasa. Penelitian menggunakan desain studi observasional komparatif dengan pendekatan pre-post intervention, dengan memanfaatkan data yang dikumpulkan dari tiga peternakan komersial sebelum dan sesudah penerapan program peningkatan kualitas air secara komprehensif. Parameter yang diamati meliputi tingkat mortalitas, bobot badan rata-rata (*Average Body Weight* / ABW), *Feed Conversion Ratio* (FCR), efisiensi pakan (*Feed Efficiency* / FE), dan Indeks Performa (IP). Kualitas air dievaluasi melalui analisis mikrobiologis terhadap sampel yang diambil dari sumber air, tangki penampungan, dan titik nipple, kemudian dibandingkan dengan standar SNI 6488:2019 dan Cobb-Vantress 2020. Data dianalisis menggunakan statistik deskriptif, uji t-test, dan korelasi Spearman. Hasil penelitian menunjukkan adanya peningkatan yang signifikan ($p < 0{,}001$) pada seluruh parameter performa setelah perlakuan peningkatan kualitas air. Tingkat mortalitas menurun dari 12,00% menjadi 3,77% di Farm Dendi, dari 10,61% menjadi 3,49% di Farm Endin, dan dari 13,65% menjadi 3,58% di Farm Noh B. Bobot badan rata-rata (ABW) meningkat secara signifikan di seluruh peternakan, sementara nilai FCR membaik dari rata-rata 1,731 menjadi 1,496. Indeks Performa menunjukkan peningkatan yang sangat nyata, dari rata-rata 301 menjadi 449, dengan ukuran efek Cohen's d sebesar 9,42 (sangat besar). Analisis korelasi menunjukkan adanya hubungan yang sangat kuat antara kualitas air dan performa produksi (rho Spearman = 0,836–0,867; $p < 0{,}05$). Penelitian ini menyimpulkan bahwa manajemen kualitas air merupakan faktor yang sangat penting dalam meningkatkan efisiensi produksi dan menjaga kesehatan ayam broiler, serta memberikan implikasi yang signifikan terhadap peningkatan profitabilitas peternakan melalui efisiensi penggunaan pakan dan penurunan tingkat mortalitas.

Kata kunci: Broiler, kualitas air, performa, efisiensi pakan, mortalitas

Introduction

The poultry industry, particularly broiler chicken farming, plays a vital role in meeting Indonesia's animal protein requirements. In 2023, national broiler production was estimated at approximately 3.8 million tons, with demand continuing to rise in line with population growth and increasing per capita protein consumption (BPS, 2024). Within intensive production systems, management efficiency is essential for business sustainability. Although feed quality has received substantial attention—accounting for 60–70% of total production costs—the quality of drinking water, the most critical nutrient and the one consumed in the greatest volume, is often overlooked (Leeson and Summers, 2001). Broilers typically consume 1.6 to 2.0 times more water than feed by weight, making water the key nutrient for maintaining physiological functions and supporting growth (Fairchild and Ritz, 2009).

CV Dua Warna Perkasa, an integrated broiler company, has faced significant production challenges, with chicken mortality rates exceeding 10% during several production cycles in 2024. Preliminary investigations indicated a strong correlation between these production failures and the quality of drinking water provided to the flocks. Microbiological analyses revealed contamination by pathogenic bacteria, including *Escherichia coli* and *Salmonella* spp., at levels surpassing the standards set by the Badan Standardisasi Nasional (BSN, 2019). Previous research has shown that water contaminated with pathogenic bacteria serves as a source of disease transmission and growth disorders in broilers (Abdallah et al., 2024; Sitorus et al., 2023).

Numerous studies have underscored the importance of water quality in poultry production. Fairchild and Ritz (2009) highlighted the direct impact of water quality on feed intake and growth rate. Contaminated water can damage the intestinal tract, causing nutrient malabsorption and reduced feed efficiency (Khan et al., 2024). Oliveira et al. (2022) demonstrated that water disinfection programs can significantly enhance broiler performance by reducing microbial loads and improving gut health. Furthermore, Ebrahimi et al. (2024) recently reported that effective management of drinking water quality improved carcass characteristics and overall broiler performance. However, comprehensive studies assessing the relationship between water quality management practices and broiler performance under commercial farm conditions in Indonesia remain limited.

This study aimed to: (1) evaluate the water quality at CV Dua Warna Perkasa Farms through microbiological analysis; (2) describe the management practices for drinking water provision, including sanitation protocols and disinfection procedures; and (3) analyze the association between water management practices and broiler growth performance, feed efficiency, and health using quantitative statistical methods.

Materials and Methods

Study Design and Location

A comparative observational research design with a quantitative approach was employed, utilizing a pre-post intervention framework. The study was conducted at three CV Dua Warna Perkasa farms (Farm Dendi, Endin, and Noh B), all located in Bogor Regency, West Java, Indonesia, from January 2024 to October 2025. The farms were selected based on similar management systems, flock sizes, and prior production issues related to water quality.

Population and Samples

The study population comprised all broiler chickens (Malindo/Ross strain) raised at the three farms during the study period, with a total capacity of approximately 40,000 birds per farm per cycle. A total sampling technique was used, collecting production data from five cycles before water quality improvement (January–November 2024) and five cycles after the intervention (January–October 2025) at each farm, resulting in 30 production cycles analyzed.

Water Quality Assessment

Water samples were collected from three critical points on each farm: the water source (well), storage tank (torrent), and drinking nipple. Microbiological analyses included Total

Plate Count (TPC), *Escherichia coli*, and *Salmonella* spp., conducted by an accredited laboratory (PT. NHI). Results were compared with standards set by SNI 6488:2019 and the Cobb-Vantress Broiler Management Guide (2020). Physical parameters such as color, odor, and turbidity were also assessed.

Water Quality Intervention

The water quality improvement program consisted of three main components. Mechanical Cleaning: The entire water distribution system was flushed with high-pressure water to remove loose debris, sediment, and organic matter. All storage tanks were drained, scrubbed manually using high-pressure washers, and rinsed thoroughly to remove biofilm and accumulated sludge. This procedure was performed at the beginning of each production cycle (between flocks). Chemical Disinfection: A stabilized chlorine dioxide (ClO_2) was applied at a concentration of 2-3 ppm (mg/L) active chlorine dioxide in the drinking water system. For initial shock treatment, a higher concentration of 5 ppm was used for the first two hours, followed by maintenance at 2 ppm. Filtration System: A multi-stage filtration system was installed at the water source entry point to each farm, consisting of a sediment pre-filter (50 µm), a carbon block filter, and a microfiltration unit (5 µm). Sediment filters were replaced every 2-4 weeks depending on water turbidity, while carbon block filters were replaced every 3 months.

Data Collection Techniques

Data were collected through:

1. Observation of water quality management practices and documentation of intervention protocols
2. Documentation of production performance records from standardized farm recording sheets
3. Laboratory tests of water quality at three critical points (source, toren, nipple)
4. Data compilation and validation from farm records

Data Analysis

Data were analyzed using:

1. Descriptive statistics to present performance characteristics, including means and standard deviations
2. Independent t-test to compare performance before and after treatment
3. Spearman's correlation analysis to determine the relationship between water quality and performance
4. Effect size (Cohen's d) to measure the magnitude of differences
5. All analyses were performed using SPSS version 25 with a significance level of 5%

Results and Discussion

Water Quality Condition

Laboratory tests conducted before intervention showed that drinking water at all farms was contaminated with pathogenic bacteria at levels exceeding quality standards. Comprehensive assessments were conducted at three critical sampling points: the water source (well), storage tank (toren), and drinking nipple. Microbiological analysis results, compared with the standards set by Badan Standardisasi Nasional (BSN, 2019) and Cobb-Vantress (2020), are presented in Table 1.

Before treatment, contamination levels were consistently elevated across all sampling points. At the source, the total bacterial count reached 2.5×10^2 CFU/ml (standard < 10^2), *E. coli* was detected at 2.1×10^2 CFU/100 ml (standard < 10), and *Salmonella* spp. at 20 CFU/100 ml (standard 0). Contamination was even higher in the storage tank, with *E. coli* at 1.7×10^2 CFU/100 ml and *Salmonella* spp. at 33 CFU/100 ml, indicating biofilm formation and bacterial proliferation within the storage and distribution system. This increase in contamination from source to tank suggests active microbial growth,

Table 1. Microbiological quality of drinking water before and after treatment at Farm Dendi

Parameter	Unit	Before Treatment	After Treatment	Standard (BSN/Cobb)
Source Point (Well)				
Total Plate Count (TPC)	CFU/mL	2.5×10^2	0	$< 1.0 \times 10^2$
E. coli	CFU/100mL	2.1×10^2	0	< 10
Salmonella spp.	CFU/100mL	20	0	0
Storage Tank (Toren)				
Total Plate Count (TPC)	CFU/mL	2.4×10^2	1	$< 1.0 \times 10^2$
E. coli	CFU/100mL	1.7×10^2	1	< 10
Salmonella spp.	CFU/100mL	33	0	0
Nipple Point				
Total Plate Count (TPC)	CFU/Ml	2.6×10^2	0	$< 1.0 \times 10^2$
E. coli	CFU/100mL	1.5×10^2	0	< 10
Salmonella spp.	CFU/100mL	7	0	0

Table 2. Independent t-test results for Farm Dendi performance before and after treatment

Parameter	Mean Before Treatment	Mean After Treatment	p-value	Remarks
Mortality (%)	12.00 ± 1.77	3.77 ± 0.49	<0.001	Highly Significant
ABW (g/bird)	2,055 ± 140	2,576 ± 175	<0.001	Highly Significant
FCR	1.716 ± 0.057	1.512 ± 0.032	<0.001	Highly Significant
FE (%)	58.3 ± 1.7	66.2 ± 1.4	<0.001	Highly Significant
IP	308 ± 23	452 ± 15	<0.001	Highly Significant

likely due to organic matter accumulation and insufficient sanitation practices. At the nipple points, the total bacterial count reached 2.6×10^2 CFU/ml, greatly exceeding standard limits. After implementing comprehensive water treatment, water quality improved markedly, meeting all quality standards: total bacterial counts decreased to 0–1 CFU/ml, *E. coli* to 0–1 CFU/100 ml, and *Salmonella* spp. to 0 CFU/100 ml at all sampling points.

Comparison of Farm Performance Before and After Treatment

Farm Dendi Performance

Independent t-test analysis revealed significant improvements ($p < 0.001$) across all performance parameters following water quality intervention (Table 2). The mortality rate decreased from 12.00% to 3.77%, representing a 68.6% reduction, while average body weight (ABW) increased from 2,055 g/bird to 2,576 g/bird (a 25.4% increase). Feed conversion ratio (FCR) improved from 1.716 to 1.512, and the Performance Index rose from 308 to 452 (a 46.8% increase).

This finding aligns with the results of Abdallah et al. (2024), who reported that water contaminated with pathogenic bacteria such as *E. coli* and *Salmonella* spp. is a primary source of biological stress, leading to increased morbidity and mortality in broilers. The marked reduction in mortality following treatment was most likely attributable to the effective control of pathogenic microbial populations in the drinking water system, which disrupted the chain of disease transmission and reduced the infection burden on the flock (Oliveira et al., 2022). The improvement in feed conversion ratio (FCR) from 1.716 to 1.512 reflects a 0.204-point reduction, corresponding to an approximate 11.9% increase in feed efficiency. For a farm with 40,000 birds consuming an average of 3.5 kg of feed per bird, this improvement translates to a feed savings of roughly 28,000 kg per production cycle.

Farm Endin Performance

Similar to Farm Dendi, Farm Endin demonstrated highly significant improvements ($p < 0.001$) in all performance parameters following water quality treatment (Table 3).

Table 3. Independent t-test results for Farm Endin performance before and after treatment

Parameter	Mean before treatment	Mean after treatment	p-value	Remarks
Mortality (%)	10.61 ± 0.78	3.49 ± 0.29	<0.001	Highly Significant
ABW (g/bird)	2,049 ± 67	2,527 ± 112	<0.001	Highly Significant
FCR	1.788 ± 0.028	1.510 ± 0.038	<0.001	Highly Significant
FE (%)	55.9 ± 0.8	66.3 ± 1.7	<0.001	Highly Significant
IP	295 ± 4	446 ± 6	<0.001	Highly Significant

Table 4. Independent t-test results for Farm Noh B performance before and after treatment

Parameter	Mean before treatment	Mean after treatment	p-value	Remarks
Mortality (%)	13.65 ± 1.82	3.58 ± 0.27	<0.001	Highly Significant
ABW (g/bird)	1,989 ± 132	2,446 ± 294	0.003	Significant
FCR	1.688 ± 0.057	1.466 ± 0.012	<0.001	Highly Significant
FE (%)	59.3 ± 1.9	68.2 ± 0.6	<0.001	Highly Significant
IP	301 ± 20	449 ± 21	<0.001	Highly Significant

The mortality rate decreased from 10.61% to 3.49%, while average body weight (ABW) increased from 2,049 g/bird to 2,527 g/bird.

The weight gain of nearly 500 g per bird suggests that the chickens' genetic potential can be fully realized when health constraints are addressed. This result is consistent with the findings of Khan et al. (2024) regarding nutrient partitioning. Prior to treatment, a portion of dietary energy and nutrients was diverted to support immune responses against infections arising from contaminated water. Once water quality improved and disease challenges were minimized, energy and nutrients could be more efficiently allocated to muscle synthesis and growth.

The reduction in feed conversion ratio (FCR) by 0.278 points, from 1.788 to 1.510, represents an improvement of approximately 15.5%—even greater than that observed in Farm Dendi. This suggests that the magnitude of performance improvement may be inversely related to initial water quality; farms with poorer baseline conditions experienced proportionally larger gains.

Farm Noh B Performance

Farm Noh B exhibited the most pronounced improvement in mortality rate, which declined from 13.65% to 3.58% after treatment (Table 4). All performance parameters improved significantly ($p < 0.001$), with the Performance Index increasing from 301 to 449, representing a 49.2% increase.

Farm Noh B exhibited the highest pre-treatment mortality rate (13.65%) compared to Farm Dendi (12.00%) and Farm Endin (10.61%). This elevated mortality is likely attributable to the accumulation of biofilm and the proliferation of *Salmonella* spp. within the water distribution system, as evidenced by the highest contamination level (33 CFU/100 ml) at the storage tank sampling point. Biofilm formation provides a protective niche for pathogenic bacteria, increasing their resistance to treatment and serving as a persistent source of infection. Notably, despite having the highest initial mortality, Farm Noh B demonstrated the most dramatic improvement following intervention, with mortality dropping by 10.07 percentage points (a 73.8% reduction).

This finding suggests that the effectiveness of water quality interventions is particularly pronounced in farms with initially poor water quality conditions. The Performance Index (IP) of 449 achieved by Farm Noh B post-treatment nearly reaches the elite standard for broiler production (> 450), illustrating that farms with a history of poor performance can attain top-tier productivity through systematic water quality management. These results are in line with Ebrahimi et al. (2024), who also reported that improved water quality management led to enhanced carcass characteristics and feed conversion in broiler production.

Comparison of Average Broiler Performance Based on Water Quality

Analysis of the pooled data from all three farms revealed highly significant differences ($p < 0.001$) in all performance parameters between poor and good water quality conditions (Table 5). The effect size, measured by Cohen's d, indicated "large" to "very large" effects for all parameters, particularly for average body weight (ABW) (d = 2.85) and Performance Index (d = 9.42). These very large effect sizes suggest that water quality is not merely a contributing factor, but a primary determinant of production success.

The Performance Index, as a composite parameter, exhibited the most remarkable improvement, increasing from an average of 301 to 449. The exceptionally large Cohen's d value (9.42) further underscores that water quality serves as a crucial leverage point in broiler production. An IP of 301 under poor water quality conditions is indicative of inefficient and unprofitable operations, while an IP of 449 reflects high efficiency and profitability. These findings support the hypothesis that investment in water quality improvements yields a high return on investment (ROI) by driving comprehensive enhancements across all aspects of production. The relatively modest effect size observed for FCR (d = 0.05) warrants additional discussion. Although FCR improved significantly (from 1.731 to 1.496, $p < 0.001$), the substantial variability within each group may have attenuated the standardized effect size. Nonetheless, the biological significance of the 0.235-point reduction in FCR—representing substantial feed cost savings—remains clear. This observation suggests that other factors, such as feed quality, environmental conditions, and management practices, may also contribute to FCR variability. Despite this, the substantial improvements observed in all other parameters—including a 485 g increase in average body weight and an 8.47% reduction in mortality—demonstrate the pronounced practical benefits of water quality interventions. Penggalih et al. (2025) similarly reported that enhanced management practices significantly improved production performance and income over feed cost in commercial broiler enterprises.

Correlation Between Drinking Water Quality and Production Performance

Spearman's correlation analysis revealed a consistently strong association, with correlation coefficients ranging from -0.867 to 0.867 (Table 6).

Table 5. Comparison of average broiler performance based on drinking water quality

Parameter	Poor water quality	Good water quality	Cohen's d value	Effect Interpretation
Mortality (%)	$12.08^{a} \pm 1.86$	$3.61^{b} \pm 0.35$	1.34	Large
ABW (g/bird)	$2{,}031^{a} \pm 113.7$	$2{,}516^{b} \pm 212$	2.85	Very large
FCR	$1.731^{a} \pm 0.06$	$1.496^{b} \pm 0.035$	0.05	Very Small
FE (%)	$57.83^{a} \pm 2.03$	$66.89^{b} \pm 1.55$	1.81	Large
IP	$301^{a} \pm 17.02$	$449^{b} \pm 14.21$	9.42	Very Large

Note: Different superscript letters (^{a,b}) in the same row indicate a significant difference based on the Independent Samples t-test results at a significance level $p < 0.05$

Table 6. Correlation between drinking water quality and production performance

Variables	N	Spearman's rho	Relationship interpretation
Water quality - Mortality	30	-0.867*	Very strong; Inverse
Water quality – ABW	30	0.836*.	Very strong; Direct
Water quality – FCR	30	-0.867*	Very strong; Inverse
Water quality – FE	30	0.867*	Very strong; Direct
Water quality - IP	30	0.867*	Very strong; Direct

Note: (*) Correlation significant at confidence level $p < 0.05$

There was a very strong positive correlation between water quality and feed efficiency (FE), average body weight (ABW), and performance index (IP). Conversely, water quality was very strongly negatively correlated with mortality and FCR. All correlations were statistically significant ($p < 0.05$), confirming the robustness of these relationships.

The correlation coefficient of -0.867 between water quality and both mortality and FCR indicates that 86.7% of the variation in these parameters can be statistically attributed to water quality status. This exceptionally high correlation suggests that water quality is the predominant limiting factor influencing broiler mortality and feed efficiency on these farms. The consistency of this relationship across all three farms (ρ = 0.836–0.867) reinforces the robustness of the association and rules out the possibility that it is merely an artifact of specific farm conditions. The slightly lower correlation with average body weight (ABW) ($\rho = 0.836$) may reflect the influence of additional management factors, such as stocking density and environmental temperature, on body weight, whereas mortality and FCR are more directly impacted by water quality through disease pressure and gut health. This nuanced interpretation highlights the multifactorial nature of broiler production, while affirming the central importance of water quality.

The convergence of the independent t-test and correlation analysis provides compelling evidence: not only are there statistically significant differences between treatment groups, but there is also a very strong linear relationship between water quality and production outcomes. This finding is consistent with Oliveira et al. (2022), who reported that comprehensive water management programs significantly improve Performance Index (IP). Furthermore, the consistent pattern observed across all three farms confirms the generalizability of these results, validating water quality as a critical management factor in commercial broiler production. Compared to the findings of Ebrahimi et al. (2024), who demonstrated improved carcass characteristics with effective water quality management, the present study quantifies the magnitude of improvement across multiple farms and demonstrates a strong dose-response relationship between water quality and key production parameters.

Critical Interpretation of Findings

The variation in response magnitude among the three farms provides important insight into the mechanisms by which water quality influences broiler performance. Farm Noh B, which had the highest baseline mortality rate (13.65%) and the greatest level of *Salmonella* contamination (33 CFU/100 ml), exhibited the largest absolute improvement in mortality (a reduction of 10.07 percentage points), while Farm Endin, with the lowest baseline mortality (10.61%), showed the smallest absolute improvement (7.12 percentage points). This pattern suggests a dose-response relationship: farms with more severe initial water quality issues experience greater improvements from intervention. This is biologically plausible, as reducing pathogen pressure from high-level contamination provides more scope for performance gains (Abdallah et al., 2024; Chen et al., 2023).

The biological mechanisms underlying these improvements can be explained through two complementary pathways. First, reducing the pathogenic bacterial load directly decreases the incidence of both clinical and subclinical diseases (Sitorus et al., 2023). Infections with *Salmonella* and *E. coli* cause intestinal inflammation, villus atrophy, and increased gut permeability, compromising nutrient absorption. Second, alleviating the immune system's metabolic burden allows more energy and nutrients to be partitioned toward growth rather than immune response, a process known as "nutrient sparing" (Khan et al., 2024). The observed 0.235-point improvement in FCR (from 1.731 to 1.496) represents a 13.6% reduction in the feed required per unit of weight gain, translating directly to improved profitability.

These findings both confirm and extend previous research. While Oliveira et al. (2022) demonstrated the efficacy of specific disinfection methods (e.g., UV and chlorine), the present study validates the practical application of a multi-component intervention (mechanical cleaning, chemical disinfection, and filtration) in an integrated commercial setting. The correlation strength of -0.867 found here is higher than typically reported in controlled experimental studies, suggesting that water quality may play an even more critical role in commercial farm settings, where multiple stressors interact. Unlike Ebrahimi et al. (2024), who reported baseline performance under relatively controlled conditions, this study demonstrates the impact of water quality under real-world commercial conditions, thus enhancing the generalizability of the results.

Implications for Management

The findings of this study have significant implications for commercial broiler farm management. First, the substantial improvement in Performance Index from 301 to 449 (an increase of 148 points) indicates that investment in water quality management can greatly enhance operational efficiency and profitability. Second, the consistent improvements observed across all three farms suggest that the water quality intervention protocol is both replicable and effective in diverse farm contexts. Third, the strong negative correlation between water quality and FCR (−0.867) underscores the critical importance of water management in reducing feed costs, which represent the largest portion of broiler production expenses. The variation in response magnitude among farms (Dendi: 46.8% IP increase, Endin: 51.2% IP increase, Noh B: 49.2% IP increase) shows that while the intervention is universally beneficial, farms with poorer initial water quality stand to gain the most, making water quality improvement a particularly high-impact strategy for underperforming operations.

Conclusions

Improving water quality at CV Dua Warna Perkasa broiler farms had a significant positive impact on overall production performance. Water quality was found to be closely associated with broiler production success, highlighting its essential role in maintaining optimal production efficiency. Therefore, effective water quality management should be considered a fundamental component of commercial broiler farming to enhance productivity, operational efficiency, and overall profitability.

Acknowledgments

The authors would like to express their sincere gratitude to the management of CV Dua Warna Perkasa for providing access to farm data and production records. Special appreciation is extended to the farm managers and staff at Dendi, Endin, and Noh B farms for their cooperation and support during the research period. We also acknowledge the contribution of PT. New Hope Indonesia (NHI) for conducting the water quality laboratory analyses.

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