VER
Vascular & Endovascular Review

Effects Of Combined Earthworm (Perionyx Excavatus) And Black Soldier Fly (Hermetia Illucens) Larvae Supplementation On Growth, Meat Quality, And Economic Efficiency Of Dong Tao Chickens

Huong Nguyen Huynh Thu[1], Thien Nguyen Phuc[2], Khoa Dang Dang[3*]

[1]Quang Trung University, Viet Nam. Email: nhthuong@qtu.edu.vn
https://orcid.org/0009-0006-3042-0761
[2]Van Hien University, Vietnam. Email: ThienNP@vhu.edu.vn
https://orcid.org/0000-0002-4639-1639
[3]Lac Hong University, Viet Nam. Email: khoadd@lhu.edu.vn
https://orcid.org/0009-0004-2996-9728
Corresponding author: khoadd@lhu.edu.vn

ABSTRACT

Dong Tao chicken is a high-value Vietnamese breed limited by slow growth and low feed efficiency. This study assessed the impact of supplementing earthworm fluid and Black Soldier Fly (BSF) larvae on the performance of intensively farmed Dong Tao chickens. Seven treatments were tested in a completely randomized design over 150 days. Combined supplementation (Treatments T5 and T6) yielded superior results: final body weight reached 3120.7–3250.5 g/bird (+17.8–22.6% vs. Control), while FCR decreased to 3.95–4.40 (-20.0–28.2%). Survival rates remained high (93.3–96.7%), and meat quality improved significantly in protein, lauric acid, and lysine levels. Economic analysis revealed that Treatment T5 (5ml earthworm fluid + 5g BSF larvae per 100g feed) maximized profitability at 588,000 VND/bird, achieving an 89.1% profit margin. Consequently, this combined supplementation is recommended to enhance the productivity and sustainability of Dong Tao chicken farming.

KEYWORDS: Dong Tao chicken, earthworm fluid, Black Soldier Fly larvae, growth, meat quality, economic efficiency.

How to Cite: Huong Nguyen Huynh Thu, Thien Nguyen Phuc, Khoa Dang Dang., (2025) Effects Of Combined Earthworm (Perionyx Excavatus) And Black Soldier Fly (Hermetia Illucens) Larvae Supplementation On Growth, Meat Quality, And Economic Efficiency Of Dong Tao Chickens, Vascular and Endovascular Review, Vol.8, No.14s, 260-264

INTRODUCTION

In the global context of moving towards sustainable agricultural development, the search for sustainable alternative protein sources for animal feed has become an inevitable trend. According to the Food and Agriculture Organization of the United Nations (FAO, 2020), global protein demand is projected to increase by 50% by 2050, requiring breakthrough solutions in feed production.

In Vietnam, the Dong Tao chicken (Gallus gallus domesticus) is recognized as a valuable native poultry breed with high economic value, not only due to its unique morphology but also its premium meat quality (Tran Cong Xuan, 1999). Under Decision No. 58/2001/QD/BNN-KNKL dated May 23, 2001, of the Minister of the Ministry of Agriculture and Rural Development, this breed is classified as a rare genetic resource prohibited from export. However, a paradox exists: high commercial value (1.5-3 million VND/kg live weight) coexists with productivity limitations. Research by Le Thi Tham et al. (2016) indicated that after 5 months of rearing, the chickens' body weight reached only 2.6-2.8 kg/bird, with a Feed Conversion Ratio (FCR) of 5.0-5.5 - significantly higher than that of industrial chicken breeds.

Globally, research on using insects as animal feed has grown strongly. Black Soldier Fly (BSF - Hermetia illucens) larvae have been proven to be a high-quality source of protein and lipids, containing lauric acid with strong antimicrobial activity (Surendra et al., 2016). Similarly, the earthworm (Perionyx excavatus) is considered a protein source with a balanced amino acid profile (Bui Huu Doan et al., 2008). However, a comprehensive survey of international (Web of Science, Scopus, ScienceDirect) and domestic scientific databases reveals no prior studies investigating the combined supplementation of these two resources in poultry farming. Previous research has only evaluated their individual effects, such as studies by Schiavone et al. (2017) on BSF in broilers, or by Khusro et al. (2012) on earthworm meal in poultry.

The combination of earthworm fluid (rich in digestive enzymes) and BSF larvae (rich in lauric acid) promises to create a "nutritional synergy" effect – a novel concept in poultry nutrition. Can this strategic combination simultaneously improve the growth, meat quality, and health of Dong Tao chickens? And more importantly, is the economic efficiency of this model compelling enough for practical application?

Arising from this research gap, this study was conducted to comprehensively evaluate the effects of supplementing with a combination of earthworm fluid and Black Soldier Fly larvae on the growth, meat quality, and economic efficiency of intensively farmed Dong Tao chickens. The research results not only contribute to the global trend of sustainable protein development but also have practical significance for the conservation and development of this valuable Vietnamese chicken breed.

MATERIALS AND METHODS

2.1. Research Materials

Experimental Subjects: 210 one-day-old Dong Tao chicks, sourced from a reputable breeding farm. The chicks were selected for uniformity in body weight and health status prior to the experiment.

Supplemental Materials:

Earthworm (Perionyx excavatus) fluid: Procured from a reliable farm, stored at 4°C, and used within 48 hours.

Nutritional Composition: Crude Protein (9.5%), Lipid (2.5%), Ash (3.1%), Calcium (0.25%), Phosphorus (0.23%).

Fresh Black Soldier Fly (BSF - Hermetia illucens) larvae: Procured from a reliable farm, homogenized before being mixed into the feed.

Nutritional Composition: Crude Protein (55-60%), Lipid (25-35%), Lauric Acid (15-25% of total fatty acids), Calcium (0.8-1.2%).

Feed: Complete commercial compound feed for broilers, appropriate for each growth stage.

2.2. Research Methods

Experimental Design: The experiment was arranged in a Completely Randomized Design (CRD) with 7 dietary treatments. Each treatment was replicated 3 times, with 10 birds per replicate (total 30 birds/treatment). Treatments were assigned to separate pens with identical housing, management, and veterinary care conditions.

CTRL (Control): Basal diet (commercial compound feed).

T1: Basal diet + Earthworm fluid (5ml/100g feed).

T2: Basal diet + Earthworm fluid (10ml/100g feed).

T3: Basal diet + BSF larvae (5g/100g feed).

T4: Basal diet + BSF larvae (10g/100g feed).

T5: Basal diet + Earthworm fluid (5ml/100g feed) + BSF larvae (5g/100g feed).

T6: Basal diet + Earthworm fluid (10ml/100g feed) + BSF larvae (10g/100g feed).

Measured Parameters: Growth Performance: Body weight (measured every 7 days), morphometric indices (body length, chest circumference, shank diameter - measured every 2 weeks). FCR was calculated.

Health Status: Survival rate, morbidity rate.

Meat Quality: Breast muscle samples were collected at the end of the experiment for analysis of chemical composition (protein, lipid, ash), fatty acid profile, amino acid profile, and sensory evaluation.

Economic Efficiency: Total cost, revenue, and profit were calculated for each treatment.

Data Analysis: Data were statistically processed using Excel software and subjected to one-way Analysis of Variance (ANOVA) using Minitab 18.0 software. Significant differences between means were assessed at $p < 0.05$. Results are presented as mean values ± standard deviation.

2.3. Research Steps

Step 1 (Input - Materials): Selection of 210 healthy, one-day-old Dong Tao chicks and supplemental materials (earthworm fluid, BSF larvae).

Step 2 (Experimental Design): Chicks were randomly allocated into 7 different dietary treatments, each with 3 replicates to ensure reliability.

Step 3 (Procedure): All treatments were raised under uniform conditions. Monitoring parameters were grouped into four main categories: Growth Performance, Health Status, Meat Quality, and Economic Efficiency.

Step 4 (Data Processing): Collected data were statistically analyzed using specialized software (Excel, Minitab). Analysis of Variance (ANOVA) was used to compare differences among treatments, with the significance level set at $p < 0.05$.

Step 5 (Results): Final results were compiled and presented as mean values ± standard deviation, indicating the impact of each supplemental diet on the flock.

RESULTS AND DISCUSSION

3.1. Growth Performance and Survival Rate

Table 1. Body weight (g) and survival rate of Dong Tao chickens across different ages.

Age (weeks)	Control	TN1	TN2	TN3	TN4	TN5	TN6
1	38.5±4.1	38.2±3.8	39.1±4.5	38.8±4.0	39.0±4.2	38.9±3.9	39.2±4.3
8	610±120a	680±115ab	725±110b	695±118ab	740±105b	780±100b	820±95c
150 day	2650±340a	2850±320b	2980±310b	2900±330b	3020±300b	3120±290c	3250±280c
Survival rate (%)	83.3	86.7	90.0	86.7	90.0	93.3	96.7

Note: Values in the same row with different superscript letters differ significantly ($p<0.05$).

The results in Table 1 show that the combination supplementation treatments (T5, T6) achieved the highest final body weight, superior to the Control treatment (CTRL) and the individual supplementation treatments. Treatment T6 (high-dose combination) reached 3250 g/bird, which was 22.6% higher than the CTRL ($p<0.05$). The survival rate was also markedly improved in the supplementation treatments, particularly in T6 (96.7%). This demonstrates a synergistic effect in providing diverse nutrients and enhancing disease resistance.

3.2. Feed Efficiency (FCR)

Table 2. Feed Conversion Ratio (FCR) of the experimental treatments.

Treatment	Control	TN1	TN2	TN3	TN4	TN5	TN6
FCR (4-21 weeks)	5.50a	5.10b	4.85c	5.05b	4.80c	4.40d	3.95e

All supplementation treatments showed better FCR compared to the Control treatment (CTRL), with Treatment T6 achieving the lowest FCR (3.95). This demonstrates a significant improvement in nutrient digestion and absorption, attributable to the high-quality protein and fats, along with the enzymes from the earthworm fluid and BSF larvae.

3.3. Meat Quality

Table 3. Chemical composition and selected quality parameters of chicken breast meat.

Parameter	Control	TN1	TN2	TN3	TN4	TN5
Crude Protein (%)	21.0±0.5^{a}	21.8±0.4^{ab}	22.2±0.3^{b}	21.5±0.6^{ab}	22.0±0.4^{b}	22.8±0.4^{c}
Total Lipid (%)	2.5±0.3^{a}	2.4±0.2^{ab}	2.3±0.3^{ab}	2.4±0.3^{ab}	2.3±0.2^{b}	2.3±0.2^{b}
Moisture (%)	73.5±0.8	73.4±0.7	73.3±0.6	73.4±0.8	73.2±0.5	73.2±0.7
Ash (%)	1.2±0.1^{a}	1.2±0.1^{a}	1.3±0.1^{ab}	1.2±0.1^{a}	1.3±0.1^{ab}	1.3±0.1^{b}
Sensory Score (10-point scale)	7.5±0.5^{a}	7.8±0.4^{ab}	8.0±0.3^{b}	7.7±0.5^{ab}	8.1±0.4^{b}	8.2±0.4^{b}
Lauric Acid (mg/100g)	12.5±1.2^{a}	15.3±1.1^{ab}	18.2±1.3^{b}	24.5±1.5^{c}	28.3±1.4^{c}	30.8±1.6^{d}
Lysine (g/100g protein	6.8±0.3^{a}	7.0±0.2^{ab}	7.2±0.3^{b}	7.1±0.2^{ab}	7.3±0.3^{b}	7.5±0.2^{c}

The meat quality analysis results (Table 3) show a clear and systematic improvement in quality parameters, with an increasing trend corresponding to higher supplementation levels, particularly in the combination treatments.

Regarding basic composition, the crude protein content increased progressively and reached its highest level in treatment T6 (23.5%), which is 11.9% higher than the control (21.0%). Notably, while the individual supplementation treatments (T1-T4) resulted in modest increases (3.8-5.2%), the combined supplementation (T5, T6) yielded superior results with corresponding increases of 8.6% and 11.9%. This indicates a positive interaction between the two supplement sources in promoting muscle protein synthesis. Conversely, the lipid content showed a slight decreasing trend, consistent with an increased lean meat ratio.

Regarding specific components, lauric acid – a medium-chain fatty acid with important antimicrobial properties – increased sharply in treatments supplemented with Black Soldier Fly (BSF) larvae. Treatments T3 and T4 (individual BSF larvae supplementation) showed impressive increases of 96-126%, but combining them with earthworm fluid in treatments T5 and T6 led to even higher results, with increases of 146% and 185%, respectively. This result not only confirms BSF larvae as a rich source of lauric acid but also suggests that earthworm fluid plays a role in supporting the absorption or metabolism of this component. Similarly, the content of lysine, an essential amino acid, also increased progressively and reached its peak in T6 (7.8 g/100g protein), reflecting the balanced supplementation of essential amino acids from both input sources.

The sensory quality of the meat improved markedly, with scores increasing from 7.5 (Control) to 8.7 points (T6). The combination

of several factors, including a slight decrease in moisture, increased protein content, and the presence of specific fatty acids like lauric acid, contributed to creating a meat product with improved color, characteristic delicious flavor, and a firmness level preferred by consumers. Thus, the combined supplementation not only enhanced nutritional value but also significantly improved the sensory quality, a key factor determining the commercial value of the product.

3.4. Economic Efficiency

Table 4. Economic Efficiency Analysis (per bird basis)

Treatment	Chick Cost (VND)	Feed Cost (VND)	Supplement Cost (VND)	Total Cost (VND)	Final Weight (kg)	Revenue* (VND)	Profit (VND)	Profit Margin (%)
Control	200,000	420,000	0	**620,000**	2.65	**1,060,000**	**440,000**	**71.0**
TN1	200,000	420,000	15,000	**635,000**	2.85	**1,140,000**	**505,000**	**79.5**
TN2	200,000	420,000	30,000	**650,000**	2.98	**1,192,000**	**542,000**	**83.4**
TN3	200,000	420,000	25,000	**645,000**	2.90	**1,160,000**	**515,000**	**79.8**
TN4	200,000	420,000	50,000	**670,000**	3.02	**1,208,000**	**538,000**	**80.3**
TN5	200,000	420,000	40,000	**660,000**	3.12	**1,248,000**	**588,000**	**89.1**
TN6	200,000	420,000	80,000	**700,000**	3.25	**1,300,000**	**600,000**	**85.7**

The economic efficiency analysis results (Table 4) reveal a clear trend regarding the relationship between supplementation levels and investment returns. While treatment T6 (supplemented with 10ml earthworm fluid + 10g BSF larvae/100g feed) achieved the highest absolute profit (600,000 VND/bird), treatment T5 (supplemented with 5ml earthworm fluid + 5g BSF larvae/100g feed) yielded the optimal profit margin (89.1%).

This difference is explained by marginal analysis: transitioning from the Control (CTRL) to T5 resulted in a significant profit increase of 148,000 VND/bird. In contrast, increasing the supplementation from T5 to T6 generated only an additional 12,000 VND/bird in profit, which is disproportionate to the extra 40,000 VND/bird cost incurred. This reflects diminishing marginal returns with higher supplementation levels and indicates that T5 achieves the optimal balance between incremental costs and returns.

From a risk perspective, the individual supplementation treatments (T1-T4) showed significant fluctuation in profit margins (79.5-83.4%), whereas the combination treatments (T5, T6) remained stable at high levels (>85%). Notably, T5 not only achieved the highest profit margin but also demonstrated better resilience to input price fluctuations due to its moderate supplemental cost. Although chick cost constituted a large proportion (32.3% of total cost in CTRL), all supplementation treatments showed superior economic efficiency compared to the control.

Given the clearly improved meat quality (increased protein, significantly higher lauric acid, high sensory scores), products from the T5 and T6 treatments have the potential to be positioned in the premium market segment, creating opportunities for enhanced value and profit. Thus, treatment T5 is not only technically feasible but also economically optimal, providing an increased profit of 148,000 VND/bird compared to the traditional method, promising high potential for widespread practical application.**4. 4.**

CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

Based on the obtained research results, the following conclusions can be drawn:

Regarding Growth and Health: The combined supplementation of earthworm fluid and Black Soldier Fly larvae positively influenced the growth and health of Dong Tao chickens. Treatment T6 (supplemented with 10ml EW + 10g BSF/100g feed) yielded the highest results, with a final weight of 3250.5 g/bird, 22.6% higher than the control ($p<0.05$), alongside a survival rate of 96.7%. The combination supplementation treatments (T5, T6) consistently yielded superior results compared to individual supplementation treatments, demonstrating a clear synergistic effect.

Regarding Feed Efficiency: Combined supplementation significantly reduced the FCR. Treatment T6 achieved the lowest FCR (3.95), representing an improvement in feed efficiency of up to 28.2% compared to the control. This indicates enhanced nutrient digestion and absorption due to the combination of enzymes, essential amino acids, and digestive aids from both supplemental sources.

Regarding Meat Quality: Meat quality was comprehensively improved in the combination supplementation treatments. Crude protein content increased to 23.5% (T6), lauric acid increased by 185%, and lysine increased by 14.7% compared to the control. The sensory evaluation score was highest in T6 (8.7/10 points), confirming clear improvements in meat color, flavor, and texture.

Regarding Economic Efficiency: Considering both absolute profit and profit margin, Treatment T5 (supplemented with 5ml EW + 5g BSF/100g feed) was evaluated as the most optimal. With a reasonable supplemental cost (40,000 VND/bird), T5 yielded a profit of 588,000 VND/bird and a profit margin of 89.1%, which is 148,000 VND/bird higher than the control. Although T6 achieved the highest absolute profit (600,000 VND/bird), its marginal efficiency was low and its profit margin (85.7%) was lower than T5's.

4.2. Recommendations

Based on the above conclusions, we propose the following recommendations:

Application in Practical Production: We recommend applying the combined supplementation formula of 5ml earthworm fluid and 5g Black Soldier Fly larvae per 100g of compound feed (Treatment T5) in the intensive farming protocol for Dong Tao chickens to achieve the highest comprehensive efficiency in productivity, quality, and economics.

Towards Circular Agriculture: Encourage the development of an integrated model combining earthworm farming, Black Soldier Fly farming, and Dong Tao chicken rearing. This model not only utilizes agricultural by-products to create nutrient-rich feed, reducing costs, but also contributes to waste treatment, environmental protection, and sustainable development.

Market Orientation: Given the significantly improved meat quality (high nutritional content, beneficial fatty acids), Dong Tao chicken products raised with this formula should be positioned and marketed in the premium market segment, helping to increase value and profits for farmers.

Future Research Directions: Continue research on the effects of this combined supplementation on the reproductive performance of Dong Tao chickens, as well as in-depth studies on the mechanisms of action at the level of gut microbiota and immunity to further clarify the scientific basis of the observed synergistic effect.

REFERENCES

1. FAO (2012). Checklist for phenotypic characterization of chickens, phenotypic characterization of animal genetic resources 2012, FAO animal Poduction and Health Guidelines No. 11. Rome.
2. Surendra, K.C.; Olivier, R.; Tomberlin, J.K.; Jha, R.; Khanal, S.K. *Bioconversion of organic wastes into biodiesel and animal feed via insect farming. Renew*. Energy 2016, 98, 197–202
3. **Schiavone, A., Cullere, M., De Marco, M., Meneguz, M., Biasato, I., & Dabbou, S. (2017).** *Partial or total replacement of soybean oil by black soldier fly larvae fat in broiler diets*. Italian Journal of Animal Science, 16(1), 93-100.
4. **Khusro, M., Andrew, N. R., & Nicholas, A. (2012).** *Earthworms as a potential source of animal protein: A review*. Asian Journal of Animal and Veterinary Advances, 7(12), 1174-1190.
5. **Ministry of Agriculture and Rural Development of Vietnam. (2001). Decision No. 58/2001/QD/BNN-KNKL dated May 23, 2001 of the Minister of the Ministry of Agriculture and Rural Development.**
6. **Tran Cong Xuan. (1999).** ***Production capacity of Dong Tao chickens*****. Poultry Farming Special Issue, Vietnam Animal Husbandry Association.**
7. **Le Thi Tham, Ngo Xuan Thai, Vu Van Thang, Dao Thi Hiep, Doan Van Soan, Vu Dinh Ton, & Dang Vu Binh. (2016).** ***Growth performance, productivity, and meat quality of Dong Tao chickens*****. Vietnam Journal of Agricultural Sciences, 14(11), 1716-1725.**
8. **Nguyen Chi Thanh. (2008).** ***Morphological characteristics and production performance of native chicken breeds*****. Master's Thesis, Hanoi University of Agriculture.**
9. ***Bui Huu Doan, Nguyen Thi Mai, Nguyen Thanh Son, & Nguyen Huy Dat. (2008). Nutritional value of earthworms (Perionyx excavatus) and potential application in animal husbandry.*** **Journal of Science and Technology in Agriculture, 6(4), 45-52.**
10. **Bui Huu Doan, Nguyen Thi Mai, Nguyen Thanh Son, & Nguyen Huy Dat. (2011).** ***Parameters used in poultry research.*** **Agricultural Publishing House.**
11. **Bui Duc Lung, Vu Thi Hung, & Le Dinh Luong. (2004). Report on the conservation of Dong Tao chicken genetic resources. Conference on Livestock Genetic Resource Conservation, National Institute of Animal Sciences.**