

SEX-SPECIFIC GROWTH RESPONSES OF MUSCOVY DUCKS TO TETRAGIDROVIT- AND NITAMIN-BASED FEEDING AND VITAMIN-SUPPORT PROGRAMS

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ABSTRACT

This study evaluated the growth performance and survival of male and female Muscovy ducks (*Cairina moschata*) reared under three feeding and vitamin-support programs during an 84-day growing period. We allocated 150 one-day-old ducklings to a control group and two experimental groups (E1 and E2), with 50 birds per group. The control group received the Megakorm feeding program without additional vitamins in drinking water, whereas E1 and E2 received the same Baby Line/Finish Chick compound-feed program supplemented with Tetragidrovit and Nitamin, respectively. Both vitamin preparations contained vitamins A, D₃, E, and C, but differed in concentration and administration regimen. We recorded body weight throughout the study and evaluated average daily gain, absolute weight gain, and survival separately by sex. Growth responses differed markedly between sexes and feeding programs. At 84 days, male body weight reached 3098.83, 3861.82, and 4024.62 g in the control, E1, and E2 groups, respectively, whereas corresponding female weights were 2314.14, 2355.25, and 2423.51 g. Whole-period average daily gain in males was 36.28, 45.36, and 47.30 g/bird/day in the control, E1, and E2 groups, respectively; corresponding values in females were 26.97, 27.45, and 28.26 g/bird/day. The treatment-associated response was therefore considerably greater in males. Survival exceeded 98% in all groups. Because the control group received a different basal feed, interpret differences between the control and experimental groups as responses to complete feeding programs rather than to vitamin supplementation alone. In contrast, the E1–E2 comparison indicated greater growth under the Nitamin-based regimen than under the Tetragidrovit-based regimen when the same compound-feed program was used. These findings highlight the importance of considering both feeding strategy and sex when evaluating nutritional support programs for Muscovy duck production.

Keywords: Muscovy duck, *Cairina moschata*, Growth performance, Body weight, Average daily gain, Vitamin supplementation, Tetragidrovit, Nitamin, Sex differences, Poultry nutrition.

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1. INTRODUCTION

Efficient meat-duck production depends on the interaction among genetic growth potential, nutrient supply, environmental management, and birds' physiological capacity to utilize dietary nutrients (Wickramasuriya et al., 2015; Ling et al., 2018; Biswas et al., 2019; Mierlita & Macri, 2026; Nametov et al., 2026). Muscovy ducks (*Cairina moschata*) are important for meat production because of their adaptability, favorable growth characteristics, and suitability for different production systems (Mona, 2015; Hassan et al., 2018; Arias-Sosa & Rojas, 2021; Shamshidin et al., 2026). However, their nutritional physiology and feeding requirements remain less extensively studied than those of chickens and other commercial poultry. Recent studies have emphasized the need for species-specific nutritional and management strategies for Muscovy ducks, particularly under intensive production conditions (Baéza, 2016; Farghly & Mahmoud, 2018; Nugmanova et al., 2024a; Rufino et al., 2025; Suhartati et al., 2025). This issue is also relevant in Kazakhstan, where improved feeding strategies may support further development and efficiency in duck production (Younis, 2015; Rafian et al., 2024; Nugmanova et al., 2024a, 2024b).

Nutritional management is particularly important during rapid growth because changes in nutrient availability can affect body-weight development, feed utilization, antioxidant status, intestinal function, and immune responses (Lauridsen, 2019). Recent studies in Muscovy ducks show that biologically active dietary interventions can influence growth performance, intestinal morphology, microbiota, antioxidant capacity, and nutrient utilization (Ge et al., 2023; Li et al., 2024a, 2024b; Safwat et al., 2024). These findings indicate that Muscovy duck growth is responsive to nutritional interventions, although the magnitude of the response depends on the type of supplement, basal diet, age,

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and physiological condition of the birds.

Vitamins are an important component of nutritional support because they participate in metabolic regulation, tissue development, antioxidant defense, immune function and mineral metabolism (Awuchi et al., 2020). Vitamin A supports growth, epithelial integrity, and immune competence, whereas vitamins C and E are key components of antioxidant protection (El-Kholy et al., 2018; Khan et al., 2023; Onagbesan et al., 2023). Vitamin D₃ plays a central role in calcium and phosphorus metabolism and skeletal development. Recent studies in ducks have shown that vitamin regimens can affect growth, bone mineralization, and physiological performance, while inadequate vitamin supply may impair development and survival (Kucharska-Gaca et al., 2017; Farghly et al., 2018; Zhou et al., 2024; Tang et al., 2025). Consequently, the response to commercial multivitamin preparations containing vitamins A, D₃, E, and C may depend on their composition, dosage, basal feeding program, and production conditions.

Sex is another important factor affecting growth in Muscovy ducks (Steczny et al., 2015; Houessionon et al., 2019). This species shows pronounced sexual dimorphism, with males attaining substantially greater body weight and following a different growth trajectory than females (Wegner et al., 2026). Recent multi-omics evidence has confirmed sex-associated differences in growth and metabolic regulation in Muscovy ducks (Tian et al., 2024). Therefore, evaluate male and female birds separately when determining responses to nutritional strategies, because differences in growth intensity and nutrient utilization may produce sex-specific responses to the same feeding program.

Despite increasing research on nutritional manipulation in Muscovy ducks, recent studies have focused mainly on plant-derived additives, fermented feeds, probiotics, mineral supplements, and alternative feed ingredients (Ge et al., 2023; Nugmanova et al., 2024b; Safwat et al., 2024; Li et al., 2024a, 2024b). Comparatively little information is available on the growth response of male and female Muscovy ducks to practical multivitamin-support regimens administered through drinking water over a complete growing period. In particular, information is limited regarding their associations with weekly growth dynamics, average daily gain, absolute weight gain, and survival under West Kazakhstan production conditions.

Accordingly, this study compared the growth dynamics, productive performance, and survival of male and female Muscovy ducks reared under three practical feeding and vitamin-support programs during an 84-day growing period. We paid particular attention to comparing Tetragidrovit- and Nitamin-based vitamin-support regimens administered through drinking water within the same compound-feed program. Live body weight, average daily gain, absolute weight gain, and survival were evaluated to characterize the growth response and determine whether sex-related differences should be considered when developing nutritional support strategies for intensive Muscovy duck production.

2. MATERIALS AND METHODS

2.1. Study Location and Experimental Design

The study was conducted at the Research and Production Center of Zhangir Khan West Kazakhstan Agrarian and Technical University, Uralsk, West Kazakhstan Region, Republic of Kazakhstan (Fig. 1).



Fig. 1: Location of the experimental facility in the West Kazakhstan region.

The experiment included 150 one-day-old Muscovy ducklings (*Cairina moschata*). The birds were allocated to three groups of 50 birds each: a control group and two experimental groups (E1 and E2). Group formation was based on age, initial body weight, and general physiological condition. We monitored body weight from the initial assessment until 84 days of age and evaluated the results separately for males and females. Mean initial body weights

of males were 51.23, 50.87, and 51.06 g in the control, E1, and E2 groups, respectively. The corresponding values for females were 48.21, 49.21, and 49.11 g.

2.2. Feeding Programs and Vitamin Supplementation

The control group received the Megakorm feeding program, consisting of Start PK-21 during weeks 0–4 and Finish PK-22 during weeks 5–12. The control group received no additional vitamin preparation through drinking water.

Both experimental groups received Baby Line Chick 1857 from placement until day 25 and Finish Chick 1858 from day 26 until the end of the experimental period. Glazov Feed Mill produced these feeds in Glazov, Russia.

The E1 group received Tetragidrovit through the drinking water. During the initial supplementation phase, Tetragidrovit was administered once at 1.5 mL/L. During the subsequent phase, it was administered at 2.0 mL/L every third week. The E2 group received Nitamin (NITA-FARM LLC, Saratov, Russia) through the drinking water. Nitamin was administered once at 1.0 mL/L during the initial phase and subsequently at 1.5 mL/L every third week.

According to the manufacturers' specifications, both Tetragidrovit and Nitamin contain vitamins A, D₃, E, and C, although the concentrations of the individual vitamins differ between the two preparations. The experimental comparison therefore represented product-specific supplementation regimens rather than equivalent doses of individual vitamins.

Because the control group and experimental groups received different compound feeds, comparisons between the control group and E1 or E2 represent comparisons of complete feeding programs rather than the isolated effect of vitamin supplementation. In contrast, E1 and E2 received the same compound-feed program and differed in the vitamin preparation administered through drinking water. Feeding programs and vitamin supplementation regimens for Muscovy ducks is shown in Table 1.

Table 1: Feeding programs and vitamin supplementation regimens for Muscovy ducks

Group	Feeding phase	Compound feed	Vitamin preparation	Concentration, mL/L	Frequency
Control	Weeks 0–4	Megakorm Start PK-21	None added in drinking water	—	—
Control	Weeks 5–12	Megakorm Finish PK-22	None added in drinking water	—	—
E1	Placement–day 25	Baby Line Chick 1857	Tetragidrovit	1.5	Once
E1	Day 26–final assessment	Finish Chick 1858	Tetragidrovit	2.0	Every third week
E2	Placement–day 25	Baby Line Chick 1857	Nitamin	1.0	Once
E2	Day 26–final assessment	Finish Chick 1858	Nitamin	1.5	Every third week

2.3. Body-Weight Measurements and Growth Calculations

Individual body weight was recorded at the initial assessment and at 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77, and 84 days of age. Birds were weighed in the morning before feeding using an electronic balance. Absolute weight gain (AWG) for each measurement interval was calculated as:

$$AWG = W_2 - W_1$$

Where W_1 and W_2 represent body weight at the beginning and end of the respective measurement interval. Average daily gain (ADG) was calculated as:

$$ADG = \frac{W_2 - W_1}{t_2 - t_1}$$

Where t_1 and t_2 represent the ages corresponding to the initial and final body-weight measurements.

2.4. Survival

Mortality was monitored daily throughout the experimental period. Survival was calculated as the number of birds alive at the final assessment divided by the number of birds initially assigned to the corresponding group and multiplied by 100:

$$Survival (\%) = \frac{N_f}{N_i} \times 100$$

Where N_i represents the initial number of birds and N_f represents the number of birds surviving to the final assessment.

2.5. Statistical Analysis

We summarized body-weight data as mean $\pm$ SE separately for each feeding group, sex, and assessment age. The original descriptive summaries were prepared in Microsoft Excel. We reanalyzed the tabulated body-weight means and SE values using Python 3.13.5 and SciPy 1.17.0.

We reconstructed separate one-way analyses of variance (ANOVA) for each sex at each assessment age, with feeding program as the explanatory factor. Within-group variances were estimated from the reported standard errors using the relationship:

$$SD^2 = SE^2 \times n$$

We performed pairwise comparisons among the three feeding programs using Tukey's honestly significant difference procedure. Tukey adjustment was applied within each sex-by-age comparison.

To account for multiple age-specific omnibus tests, Holm-adjusted P-values were calculated across the 26 ANOVA tests, representing 13 assessment ages for each sex. Both unadjusted and Holm-adjusted omnibus P-values were reported. We defined statistical significance as $P < 0.05$. We also evaluated day-84 body weight as the final assessment using Welch's ANOVA and pairwise Welch tests with Holm adjustment within each sex. These analyses were treated as sensitivity analyses.

All inferential calculations assumed independent observations. Because the available summary data did not establish the experimental units or independent treatment replication, the inferential comparisons should be interpreted conditionally on those assumptions.

3. RESULTS

3.1. Body-weight Dynamics

Body weight increased progressively in all treatment groups throughout the 84-day growing period, but the magnitude and timing of the response differed by sex and feeding program (Table 2; Fig. 2 and 3). At the initial assessment and at 7 days of age, body weights were comparable among treatments in both males and females.

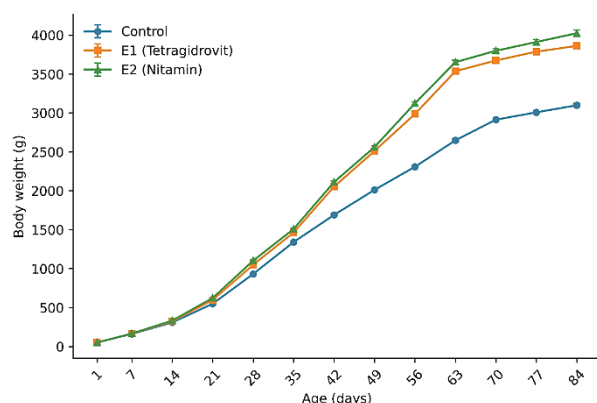


Fig. 2: Growth trajectory of male Muscovy ducks receiving the control, E1 (Tetragidrovit), and E2 (Nitamin) feeding programs from 1 to 84 days of age.

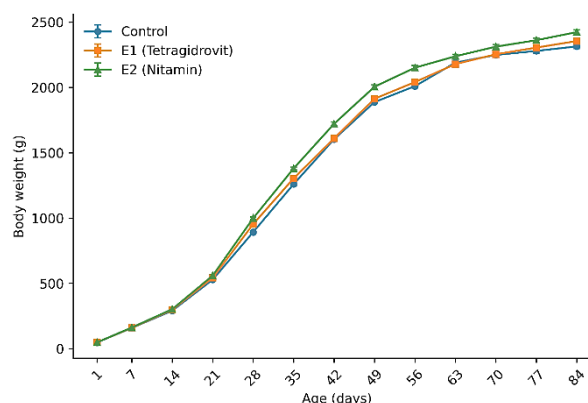


Fig. 3: Growth trajectory of female Muscovy ducks receiving the control, E1 (Tetragidrovit), and E2 (Nitamin) feeding programs from 1 to 84 days of age.

In males, separation among feeding programs became evident during the early growth phase. At day 14, E2 had the highest mean body weight, although the multiplicity-adjusted omnibus result depended on the assumed sample size. From day 21 onward, treatment-related differences were consistently evident after multiplicity adjustment (Table 2). During the middle and late growing periods, males in both experimental groups were heavier than controls, with E2 generally showing the greatest body weight. The difference became particularly pronounced after 42 days of age (Fig. 2). By day 84, mean body weight reached 3098.83 g in the control group, 3861.82 g in E1, and 4024.62 g in E2. Thus, E2 males were 925.79 g (29.9 %) heavier than controls and 162.80 g (4.2 %) heavier than E1 males at the final assessment (Table 2).

The treatment response was less pronounced in females (Fig. 3). Body weights remained similar among groups during the first 14 days, and the day-21 difference was no longer significant after Holm adjustment. Treatment separation was clear from days 28 to 56, when E2 consistently showed the highest body weight (Table 2). At days 63 and 70, omnibus differences were no longer significant after multiple-testing adjustment, whereas differences reappeared at days 77 and 84. At the final assessment, females weighed 2314.14, 2355.25, and 2423.51 g in the

control, E1, and E2 groups, respectively. E2 females were therefore 109.37 g (4.7%) heavier than controls and 68.26 g (2.9%) heavier than E1 females.

Table 2: Body weight (g) of male and female Muscovy ducks during the 84-day growing period

Age (days)	Control (g, mean $\pm$ SE)	E1 (g, mean $\pm$ SE)	E2 (g, mean $\pm$ SE)	Holm-adjusted <i>P</i> (n = 25 / n = 50)
A. Males				
1	51.23 $\pm$ 0.30 ^a	50.87 $\pm$ 0.65 ^a	51.06 $\pm$ 0.54 ^a	1.0000 / 1.0000
7	161.52 $\pm$ 1.50 ^a	165.24 $\pm$ 2.14 ^a	166.32 $\pm$ 1.98 ^a	0.8887 / 0.8701
14	308.25 $\pm$ 5.90 ^b	321.59 $\pm$ 4.95 ^{ab}	332.54 $\pm$ 4.56 ^a	0.0520 / 0.0430
21	548.75 $\pm$ 8.23 ^b	596.36 $\pm$ 7.98 ^a	623.54 $\pm$ 8.21 ^a	<0.001 / <0.001
28	931.24 $\pm$ 12.45 ^c	1049.81 $\pm$ 11.24 ^b	1101.85 $\pm$ 10.85 ^a	<0.001 / <0.001
35	1341.35 $\pm$ 13.52 ^b	1464.21 $\pm$ 13.84 ^a	1508.84 $\pm$ 12.84 ^a	<0.001 / <0.001
42	1689.87 $\pm$ 13.86 ^c	2053.24 $\pm$ 15.87 ^b	2111.76 $\pm$ 13.89 ^a	<0.001 / <0.001
49	2012.45 $\pm$ 15.28 ^b	2511.32 $\pm$ 17.54 ^a	2562.11 $\pm$ 15.26 ^a	<0.001 / <0.001
56	2308.37 $\pm$ 18.45 ^c	2986.99 $\pm$ 22.87 ^b	3124.25 $\pm$ 19.98 ^a	<0.001 / <0.001
63	2648.23 $\pm$ 21.50 ^c	3536.38 $\pm$ 28.64 ^b	3652.68 $\pm$ 25.64 ^a	<0.001 / <0.001
70	2914.13 $\pm$ 23.54 ^c	3674.29 $\pm$ 35.48 ^b	3798.85 $\pm$ 26.98 ^a	<0.001 / <0.001
77	3007.98 $\pm$ 22.65 ^c	3787.37 $\pm$ 42.15 ^b	3911.85 $\pm$ 31.25 ^a	<0.001 / <0.001
84	3098.83 $\pm$ 24.56 ^c	3861.82 $\pm$ 38.95 ^b	4024.62 $\pm$ 42.25 ^a	<0.001 / <0.001
B. Females				
1	48.21 $\pm$ 0.98 ^a	49.21 $\pm$ 0.85 ^a	49.11 $\pm$ 0.46 ^a	1.0000 / 1.0000
7	159.32 $\pm$ 2.14 ^a	160.21 $\pm$ 1.98 ^a	162.51 $\pm$ 0.23 ^a	1.0000 / 1.0000
14	291.23 $\pm$ 5.23 ^a	297.59 $\pm$ 7.52 ^a	302.81 $\pm$ 6.52 ^a	1.0000 / 1.0000
21	528.95 $\pm$ 8.95 ^b	542.51 $\pm$ 7.86 ^{ab}	559.85 $\pm$ 6.03 ^a	0.1307 / 0.1178
28	892.31 $\pm$ 10.95 ^c	953.54 $\pm$ 12.54 ^b	998.87 $\pm$ 9.62 ^a	<0.001 / <0.001
35	1259.96 $\pm$ 9.89 ^c	1303.87 $\pm$ 11.25 ^b	1379.89 $\pm$ 10.60 ^a	<0.001 / <0.001
42	1603.54 $\pm$ 10.85 ^b	1609.87 $\pm$ 12.54 ^b	1721.46 $\pm$ 13.68 ^a	<0.001 / <0.001
49	1887.96 $\pm$ 12.54 ^b	1913.54 $\pm$ 10.96 ^b	2005.48 $\pm$ 14.95 ^a	<0.001 / <0.001
56	2009.84 $\pm$ 13.95 ^b	2041.08 $\pm$ 15.74 ^b	2151.21 $\pm$ 17.85 ^a	<0.001 / <0.001
63	2189.84 $\pm$ 12.85 ^b	2179.00 $\pm$ 14.25 ^b	2238.73 $\pm$ 14.93 ^a	0.0616 / 0.0521
70	2248.71 $\pm$ 13.81 ^b	2253.79 $\pm$ 15.86 ^b	2312.16 $\pm$ 16.54 ^a	0.0616 / 0.0521
77	2279.38 $\pm$ 15.84 ^b	2304.88 $\pm$ 16.89 ^b	2361.50 $\pm$ 15.85 ^a	0.0209 / 0.0160
84	2314.14 $\pm$ 15.98 ^b	2355.25 $\pm$ 18.52 ^b	2423.51 $\pm$ 16.76 ^a	0.0012 / <0.001

Note: E1 = Tetragidrovit-based feeding program; E2 = Nitamin-based feeding program. Values are mean $\pm$ SE. Within a row, means carrying different superscript letters differ according to the reported Tukey pairwise comparisons.

Table 3: Average daily gain of Muscovy ducks during successive growth periods (g/bird/day)

Sex	Period (days)	Control	E1	E2
Male	1–7	15.75	16.33	16.46
	8–14	20.96	22.33	23.74
	15–21	34.35	39.25	41.57
	22–28	54.64	64.77	68.33
	29–35	58.58	59.20	58.14
	36–42	49.78	84.14	86.13
	43–49	46.08	65.44	64.33
	50–56	42.27	67.95	80.30
	57–63	48.55	78.48	75.49
	64–70	37.98	19.70	20.88
	71–77	13.40	16.15	16.14
	78–84	12.97	10.63	16.11
	1–84	36.28	45.36	47.30
	1–7	15.87	15.85	16.20
Female	8–14	18.84	19.62	20.04
	15–21	33.96	34.98	36.72
	22–28	51.90	58.71	62.71
	29–35	52.52	50.04	54.43
	36–42	49.08	43.71	48.79
	43–49	40.63	43.38	40.57
	50–56	17.41	18.22	20.81
	57–63	25.71	19.70	12.50
	64–70	8.41	10.68	10.49
	71–77	4.38	7.29	7.04
	78–84	4.96	7.19	8.85
	1–84	26.97	27.45	28.26

Note: Values in this table are descriptive. E1 = Tetragidrovit-based feeding program; E2 = Nitamin-based feeding program.

Consequently, the treatment-associated response was much greater in males than in females, particularly during the second half of the growing period (Fig. 2 and 3).

3.2. Average Daily Gain and Growth Pattern

Average daily gain varied markedly with age and sex (Table 3). In males, growth accelerated during the early and middle phases of rearing. Control males reached their highest reported ADG during days 29–35, whereas both experimental groups reached their maximum during days 36–42. Peak ADG was 84.14 g/bird/day in E1 and 86.13 g/bird/day in E2, compared with a peak of 58.58 g/bird/day in controls.

Experimental males showed the greatest growth gains during the middle growing period. E1 and E2 maintained higher ADG than controls through several consecutive intervals between days 36 and 63, after which growth rates declined in all groups (Table 3). Across the entire experimental period, mean ADG was 36.28 g/bird/day in controls, 45.36 g/bird/day in E1, and 47.30 g/bird/day in E2. Relative to controls, whole-period ADG was therefore 25.0 % higher in E1 and 30.4 % higher in E2.

In females, maximum growth occurred earlier than in experimental males. Peak ADG in E1 and E2 was

observed during days 22–28, reaching 58.71 and 62.71 g/bird/day, respectively, whereas control females reached their maximum ADG of 52.52 g/bird/day during days 29–35 (Table 3). Thereafter, ADG declined progressively, particularly after 49 days of age. Whole-period ADG was 26.97, 27.45, and 28.26 g/bird/day in the control, E1, and E2 groups, respectively. The corresponding increases over the control were 1.8% for E1 and 4.8% for E2, confirming that the treatment-associated increase in growth rate was substantially greater in males.

Table 4: Summary of growth performance of Muscovy ducks over the 84-day growing period

Sex	Growth variable	Control	E1	E2
Male	Average daily gain (g/bird/day)	36.28	45.36	47.30
	Absolute weight gain (g/bird)	3047.60	3810.95	3973.56
	Peak ADG (g/bird/day)	58.58	84.14	86.13
	Period of peak ADG (days)	29–35	36–42	36–42
Female	Average daily gain (g/bird/day)	26.97	27.45	28.26
	Absolute weight gain (g/bird)	2265.93	2306.04	2374.40
	Peak ADG (g/bird/day)	52.52	58.71	62.71
	Period of peak ADG (days)	29–35	22–28	22–28

Note: E1 = Tetragidrovit-based feeding program; E2 = Nitamin-based feeding program. ADG = average daily gain. Absolute weight gain was calculated over the complete experimental period.

2374.40 g in E2. Relative to the control, this represented increases of approximately 1.8% and 4.8% for E1 and E2, respectively (Table 4). Overall, both ADG and AWG therefore demonstrated a markedly stronger treatment-associated response in males than in females.

4. DISCUSSION

The present study demonstrated distinct growth responses of Muscovy ducks to the three feeding and vitamin-support programs, with the magnitude of the response strongly dependent on sex and age. Body weights were comparable among groups during the early rearing period, but differences became progressively greater during subsequent growth, particularly in males. By day 84, E2 had the highest final body weight in both sexes, followed by E1 and the control group (Table 2). The same general pattern was observed for average daily gain (ADG) and absolute weight gain (AWG; Table 3 and 4), indicating that final body-weight differences reflected cumulative changes in growth trajectory rather than a transient response at the end of rearing.

Nutritional interventions in ducks are strongly influenced by complete diet composition (Ismoyowati et al., 2019; Biesek et al., 2021; Fan et al., 2024; Phuong et al., 2025). Earlier reviews emphasized that nutrient requirements vary by genotype, age, production stage, and productive potential, and that both deficiency and excess can impair biological and economic efficiency (Fouad et al., 2018). More recent research confirms this principle. Zhao et al. (2025) showed that changes in dietary metabolizable energy and crude protein altered weight gain and feed efficiency in Pekin ducks and that the most effective nutrient density differed between growth phases. Recent reviews of Muscovy duck production similarly emphasize the need for species- and growth-stage-specific nutritional management (Rufino et al., 2025).

The greater growth observed in E1 and E2 is also consistent with studies showing that biologically active dietary interventions can modify growth performance in Muscovy ducks. Liu et al. (2023) reported increased ADG and improved intestinal characteristics with appropriate inclusion levels of fermented *Andrographis paniculata*, whereas excessive supplementation reduced body weight. Ge et al. (2023) found that plant essential oils increased final body weight and ADG and reduced feed conversion ratio in male Muscovy ducks, accompanied by improvements in antioxidant capacity, intestinal barrier function, and gut microbial composition. These studies show that Muscovy duck growth can respond substantially to nutritional interventions, but that the effect depends on formulation and dose (Barakat & El-Garhy, 2019; Kokoszyński et al., 2020; Sulaiman et al., 2022; Ge et al., 2023; Liu et al., 2023).

The vitamin component of the experimental programs may plausibly contribute biologically to the observed responses, although this experiment did not investigate the underlying mechanisms. Importantly, studies in ducks show that the biological effect of a vitamin regimen is not necessarily expressed solely as increased body weight (Zhang et al., 2020). Zhou et al. (2024) compared two vitamin regimens in meat ducks and found no significant difference in short-term growth performance, although the higher vitamin regimen improved tibial mineralization, bone strength, and bone-formation indices. Conversely, Tang et al. (2025) demonstrated that inadequate vitamin D₃ supply reduced body weight and ADG and impaired calcium metabolism and tibial mineralization in male Pekin ducks, whereas appropriate supplementation improved these outcomes. Thus, responses to vitamin supplementation depend on baseline vitamin status, dose, vitamin source, age, and the nutritional context in which the vitamins are provided (Gariglio et al., 2019; Abdel-Hamid et al., 2020; Zhou et al., 2024; Tang et al., 2025).

3.3. Absolute Weight Gain

Whole-period absolute weight gain followed the same general pattern as final body weight and ADG (Table 4). Among males, total weight gain was 3047.60 g in the control group, 3810.95 g in E1, and 3973.56 g in E2. E2 therefore produced 925.96 g greater absolute gain than the control and 162.61 g greater gain than E1. Relative to controls, whole-period AWG was approximately 25.0% greater in E1 and 30.4% greater in E2.

Differences among females were smaller. Total AWG was 2265.93 g in controls, 2306.04 g in E1, and

Therefore, an important aspect of the present experimental design must be considered when interpreting the control comparison. The control group received Megakorm feeds, whereas E1 and E2 received Baby Line Chick and Finish Chick feeds in addition to their respective vitamin preparations. Consequently, the greater growth of E1 and E2 relative to the control cannot be attributed specifically to vitamin supplementation. Differences in energy, protein, amino acids, minerals, vitamins, or other characteristics of the compound feeds may also have contributed. This interpretation is particularly relevant given the demonstrated sensitivity of duck growth to basal dietary nutrient density (Fouad et al., 2018; Zhao et al., 2025). The control comparison should therefore be regarded as a comparison of complete feeding and vitamin-support programs.

In contrast, the comparison between E1 and E2 is more informative regarding the two vitamin-support strategies because both groups received the same compound-feed program. At day 84, E2 males were 162.80 g heavier than E1 males, while E2 females were 68.26 g heavier than E1 females (Table 2). The results therefore indicate that the Nitamin-based regimen was associated with greater growth than the Tetragidrovit-based regimen under the conditions of this experiment. However, because the preparations differed in vitamin concentrations and administration rates, the response cannot be assigned to a specific vitamin or vitamin interaction. Product-specific differences should therefore be interpreted at the regimen level rather than as evidence of an individual vitamin's efficacy.

Sex was another major determinant of the growth response. The differences among feeding programs were considerably greater in males, and whole-period ADG reached 47.30 g/bird/day in E2 males compared with 36.28 g/bird/day in control males; corresponding differences in females were much smaller. This finding agrees with the pronounced sexual dimorphism of Muscovy ducks. Tian et al. (2024), using longitudinal body-weight records from 301 Muscovy ducks, demonstrated that males had a later growth-curve inflection point and greater mature body weight than females. Transcriptomic and microbiome analyses also revealed sex-associated biological differences related to growth and metabolism. Zhang et al. (2024) further demonstrated age- and sex-dependent differences in Muscovy duck muscle-fiber development and expression of genes involved in muscle growth. These findings provide a biological context for the stronger and more prolonged growth response observed in males in the present study.

Growth pattern also differed with age. Experimental males reached their maximum ADG during days 36–42, whereas E1 and E2 females reached peak ADG earlier, during days 22–28 (Table 3). This earlier decline in female growth is consistent with the sex-specific growth trajectories reported by Tian et al. (2024) and supports evaluating males and females separately when assessing nutritional interventions. Survival exceeded 98% in all groups, indicating generally favorable flock survival; however, the available data do not support attributing a survival advantage to any particular program.

The findings should ultimately be interpreted within the study's limitations. Feed intake and feed conversion were unavailable, physiological mechanisms were not measured, basal feeds differed between the control and experimental treatments, and the available records could not confirm independent treatment replication. Future studies should use identical basal diets, replicate experimental units, maintain individual longitudinal records, and measure feed utilization and relevant physiological indicators. Within these limitations, the present results indicate that feeding/vitamin-support strategy and sex were strongly associated with Muscovy duck growth, while the E1–E2 comparison suggests a greater growth response to the Nitamin-based than the Tetragidrovit-based regimen under the same compound-feed program.

5. CONCLUSION

The present study showed that growth performance of Muscovy ducks differed among the three feeding and vitamin-support programs and that sex strongly influenced the magnitude of the response. Birds in the E2 program achieved the greatest final body weight, average daily gain, and absolute weight gain, with the clearest response observed in males. Females also showed improved growth in E2, although the differences were smaller than those observed in males. Because the control group received a different compound-feed program than E1 and E2, interpret differences between the control and experimental groups as effects of the complete feeding programs rather than vitamin supplementation alone. In contrast, the comparison between E1 and E2 indicates that the Nitamin-based regimen was associated with greater growth performance than the Tetragidrovit-based regimen under the same compound-feed program. Survival remained high in all groups throughout the 84-day growing period. Overall, the findings indicate that feeding strategy, vitamin-support regimen, and sex should be considered together when optimizing Muscovy duck production. The stronger response observed in males also highlights the importance of accounting for sex-specific growth patterns when evaluating nutritional interventions. Further controlled studies using identical basal diets and replicated experimental units are needed to determine the independent contribution of specific vitamin formulations to growth and production efficiency.

Declarations

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