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EFFECT OF DIETARY SUPPLEMENTATION WITH *Dunaliella salina* ON EARLY GROWTH PERFORMANCE OF PEKIN DUCKLINGS

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ABSTRACT: We aimed in this trial to investigate whether different levels of Dunaliella salina can affect the early growth performance of Pekin duck during 0-2 weeks of age. A total number of 200 healthy one- day-old Pekin ducks were randomly distributed into 4 experimental groups. Each group contained 5 replicates with 10 birds each. The first group received the standard diet with no supplementation (control), while the 2nd, 3rd, and 4th groups received the standard diet supplemented with 0.5, 1.0, and 1.5 g D. salina per kg diet. The data revealed no significant effect of dietary supplementation of D. salina at different levels of live body weight at the first (P = 0.926) and second (P = 0.232) weeks of age. Body weight gain (BWG) was also insignificantly affected by dietary treatments during 0-1 (P = 0.701) and 0-2 (P = 0.076) weeks of age. On the other hand, during 1–2 weeks of age, ducks supplemented with 1.0 and 1.5 g D. salina /kg diet showed significantly (P = 0.018) higher BWG compared to the control group. Dietary supplementation with D. salina had no significant effect on feed intake (FI) during 0-1 (P = 0.196), 1-2 (P = 0.773), and 0-2 (P = 0.605) weeks of age. Also, the feed conversion ratio (FCR) was insignificantly affected by adding D. salina to duck's diets at different levels during 0-1 (P = 0.147), 1-2 (P = 0.197), and 0-2 (P = 0.230) weeks of age. These findings suggest that higher inclusion levels of D. salina may enhance early growth performance during 0-2 weeks of age, while having minimal impact on overall FI and FCR during such period.

Key words: *Dunaliella salina*, early growth performance, Pekin ducklings

INTRODUCTION

In recent years, there has been a growing demand for sustainable, health-promoting feed additives with added nutritional and functional value in poultry nutrition **(Salah *et al*., 2019; Emam *et al*., 2023; Mohamed *et al*., 2024)**. Natural and biological supplements are increasingly being utilized in poultry diets to improve growth performance, immune status, and overall health **(El-Tarabany *et al*., 2021; Rafeeq *et al*., 2022; Abd Elzaher *et al*., 2023)**. Among these, microalgae have attracted substantial interest due to their rich nutritional profile and wide range of bioactive compounds **(Lestingi *et al*., 2024)**.

Dunaliella salina, a unicellular halophilic green microalga, is considered one of the most promising species for feed supplementation. It is notably rich in natural β-carotene, which can account for up to 14% of its dry matter, including both cis and trans isomers, with higher antioxidant capacity than synthetic forms **(Bansal *et al*., 2009; Yücel *et al*., 2021)**. In addition to β-carotene, *Dunaliella salina* contains a wide array of biologically active substances such as chlorophyll, polyunsaturated fatty acids (PUFA), monounsaturated and saturated fatty acids, essential amino acids, vitamins (notably C and B12), minerals (e.g., iron, calcium, phosphorus), polyphenols, and enzymes **(Molino *et al*., 2018; Kumudha and Sarada, 2016; Darsi *et al*., 2012; Salim *et al*., 2021).**

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Dunaliella salina also demonstrates a broad spectrum of functional properties, including antioxidant, antimicrobial, and immunostimulatory effects **(Hyrslova *et al*., 2022; El-Baz *et al*., 2022)**. Its bioactive pigments such as violaxanthin, lutein, and zeaxanthin have been shown to possess anti-inflammatory and oxidative stress-reducing capacities **(Ferdous and Yusof, 2021)**. The presence of glycerol-3-phosphate dehydrogenase (GPDH) isoforms indicates its role in glycerol biosynthesis, further contributing to its adaptability and biochemical versatility **(Bhalamurugan *et al*., 2018)**.

Despite the well-established benefits of *Dunaliella salina* in human nutrition and cosmetics, limited studies have addressed its potential as a functional feed additive in poultry, particularly in ducks. Given its rich nutritional composition and biological activity, it is hypothesized that *Dunaliella salina* supplementation may positively influence growth performance during the early life stage of Pekin ducks. Therefore, the present study aims to investigate the effects of dietary *Dunaliella salina* supplementation on early growth performance of Pekin ducks in terms of live body weight, body weight gain, feed intake and feed conversion ratio.

MATERIALS AND METHODS

Experimental Design, Ducklings and Managerial Conditions

The present study was carried out in a private duck farm, Sharkia governorate, Egypt. A total number of 200 one-day-old Pekin ducks were randomly distributed to 4 equal groups in a one way completely randomized design. Each group contained 50 ducklings with 5 replications (10 birds each). The first group received the standard diet with no supplementation (control), while the 2^{nd}, 3^{rd}, and 4^{th} groups received the standard diet supplemented with 0.5, 1.0, and 1.5 g *D. salina* per kg diet. Birds in each replicate were placed in a separate litter floor pen (150×100 cm). Birds in all treatment groups were fed on the same basal diets (Table 1) which were formulated to meet or exceed Pekin duck requirements during the starter period according to **NRC (1994)**. *Dunaliella salina*, the lyophilized microalgae powder of *D. salina* was kindly supplied by the National Research Center in Cairo, Egypt.

All birds were reared in an open-sided duck farm. The indoor ambient temperature was around 33 °C through the first three days of age, after that the temperature was gradually reduced to 27 °C at the end of the trial (14th day of age). The relative humidity during the experimental period ranged between 60% and 80%. The standard management and husbandry procedure was applied during the experimental period. Feed and water were introduced ad *libitum* through the experimental period.

Data Collection

Live body weight (LBW) and Body weight gain (BWG)

Ducklings were weighed post-hatch on the first day of age (LBW 0) and were equally distributed among the replicates (10 birds each) to ensure that the average body weight was approximately equal across all replicates. Birds were weighed again at the end of the first (LBW 1) and second (LBW 2) week of age. Body weight gain (g/day) was calculated by subtracting the average live body weight of each replicate between two successive weights (BWG 0-1 and BWG 1-2). Also, body weight gain was calculated for the whole period (BWG 0-2) by subtracting the average initial live body weight (LBW 0) from the average final live body weight (LBW 2) of each replicate.

Feed intake (FI) and feed conversion ratio (FCR)

At the beginning of each experimental period, a certain amount of each experimental diet was weighed for each replicate within each treatment group. At the end of the certain period, the remaining diet was weighed and subtracted from that offered to obtain the total feed intake per replicate during the certain period. The previous amount was divided by number of chicks in the replicate to obtain average amount of feed intake per chick. The previous amount was divided by period length (day) to obtain the average amount of feed intake per chick per day (FI 0-1, 1-2, and 0-2). Feed conversion ratio (FCR) was calculated as grams of feed required to produce one gram of body gain during each experimental period (FCR 0-1, 1-2, and 0-2). The calculation of FCR was achieved by determining the ratio between average daily FI and average daily BWG.

Statistical Analysis

Analysis of variance for data was accomplished using the SAS General Liner Models Procedure **(SAS Institute, 2004).** The model was assessed for different traits according to **Snedecor and Cochran (1982).** The statistical fixed model used was:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where:

Y_{ij} = An observation.

μ = Overall mean.

T_i = The fixed effect of treatment.

e_{ij} = Random error.

Duncan's new multiple range test was used to test the differences among the means according to **Duncan (1955).** Statistical significance was accepted at a probability level of 0.05 (P < 0.05).

RESULTS

Live Body Weight (LBW)

The data presented in Table 2 show the effect of dietary supplementation with different levels of *Dunaliella salina* (0.5, 1.0, and 1.5 g/kg diet) on LBW at different experimental periods. No significant differences (P = 0.960) were observed among the experimental groups in the initial weight (LBW 0), indicating similar initial body weights. At the first week of age (LBW 1), all groups, including the control one, showed comparable body weights with no significant variations (P = 0.926). At the second week of age (LBW 2), a numerical increase (P = 0.232) in body weight was observed in ducks supplemented with 1.0 and 1.5 g/kg *D. salina* (442.1 ± 3.994 and 442.2 ± 6.990 g, respectively) compared to the control and 0.5 g/kg groups (436.4 ± 5.933 and 435.8 ± 7.263 g, respectively). These findings suggest that while higher levels of *D. salina* may numerically improve growth performance, the changes were not significant under the conditions of this study.

Body Weight Gain (BWG)

Table 3 presents the effect of dietary supplementation with different levels of *Dunaliella salina* (0.5, 1.0, and 1.5 g/kg diet) on BWG during different experimental periods (0-1, 1-2, and 0-2 weeks of age). The results indicate that during the first week of age (BWG 0–1), there were no significant differences (P = 0.701) in body weight gain among the control and *Dunaliella salina*-supplemented groups. However, during the subsequent phase (BWG 1–2), ducks supplemented with 1.0 and 1.5 g *D. salina* /kg diet showed significantly (P = 0.018) higher BWG (36.78 ± 0.295 and 36.76 ± 0.590 g/day, respectively) compared to the control and 0.5 g/kg groups (35.92 ± 0.507 and 35.70 ± 0.840 g/day). Over the entire period from 0 to 2 weeks (BWG 0–2), there was a numerical (P = 0.076) improvement in BWG in response to dietary supplementation with *Dunaliella salina* at levels of 1.0 and 1.5 g/kg diet. These findings suggest that higher levels of *D. salina* (≥1.0 g/kg) can enhance growth performance during the early growing period, particularly after the first week.

Feed Intake (FI)

The data presented in Table 4 show the effect of dietary supplementation with different levels of *Dunaliella salina* (0.5, 1.0, and 1.5 g/kg diet) on FI during different experimental periods (0-1, 1-2, and 0-2 weeks of age). The results indicate that dietary supplementation with *Dunaliella salina* had no significant effect on FI during 0-1 (P = 0.196), 1-2 (P = 0.773), and 0-2 (P = 0.605) weeks of age. These findings suggest that the inclusion of *D. salina* at levels up to 1.5 g/kg in the diet does not significantly affect feed consumption in ducks during the early growth stage.

Feed Conversion Ratio (FCR)

Tabulated date in Table 5 illustrates the impact of adding different levels of *Dunaliella salina* in Pekin ducks' diets (0.5, 1.0, and 1.5 g/kg diet) on FCR during early life stages (0-1, 1-2, and 0-2 weeks of age). The results indicate that dietary supplementation with *Dunaliella salina* had no significant effects on FCR during 0-1 (P = 0.147), 1-2 (P = 0.197), and 0-2 (P = 0.230) weeks of age. These findings suggest that the inclusion of *D. salina* up to 1.5 g/kg does not significantly alter feed utilization in ducks during the early developmental phase..

Table 1. Ingredients and calculated nutrients' content of the control die

Ingredients	%
Yellow Corn (8.5%)	56.5
Soybean meal (44%)	37.0
Corn gluten meal (62%)	1.50
Soybean oil	2.00
Limestone	0.59
Dicalcium phosphate	1.41
Salt	0.20
Premix[1]	0.30
Choline-chloride (50%)	0.30
Dl-Methionine	0.03
Sodium bicarbonate	0.17
Total	**100**
Calculated analysis:	
Crude protein	22.03%
Calcium	0.65%
Available Phosphorus	0.40%
Lysine	1.16%
Methionine	0.41%
Total sulfur amino acids	0.75%
Metabolizable energy (kcal/kg diet)	2951

[1] Provides per kg of diet: Vitamin A, 12,000 I.U; Vitamin D3, 5000 I.U; Vitamin E, 130.0 mg; Vitamin K3, 3.605 mg; Vitamin B1 (thiamin), 3.0 mg; Vitamin B2 (riboflavin), 8.0 mg; Vitamin B6, 4.950 mg; Vitamin B12, 17.0 mg; Niacin, 60.0 mg; D-Biotin, 200.0 mg; Calcium D-pantothenate, 18.333 mg; Folic acid, 2.083 mg; manganese, 100.0 mg; iron, 80.0 mg; zinc, 80.0 mg; copper, 8.0 mg; iodine, 2.0 mg; cobalt, 500.0 mg; and selenium, 150.0 mg.

Table 2. Effect of dietary supplementation with different levels of *Dunaliella salina* on live body weight of Pekin ducklings

Items	Control	*Dunaliella salina*/kg of duck diet			Sig.
		0.5 g	1.0 g	1.5 g	
LBW 0 week	47.38 ± 1.385	47.26 ± 1.412	47.10 ± 1.409	47.56 ± 1.365	0.960
LBW 1 week	185.0 ± 2.853	185.9 ± 1.563	184.8 ± 3.656	185.1 ± 3.263	0.926
LBW 2 week	436.4 ± 5.933	435.8 ± 7.263	442.1 ± 3.994	442.2 ± 6.990	0.232

LBW: Live body weight.

Table 3. Effect of dietary supplementation with different levels of *Dunaliella salina* on body weight gain of Pekin ducklings

Items	Control	*Dunaliella salina*/kg of duck diet			Sig.
		0.5 g	1.0 g	1.5 g	
BWG 0-1 week	19.64 ± 0.230	19.80 ± 0.071	19.66 ± 0.329	19.64 ± 0.288	0.701
BWG 1-2 weeks	35.92 ± 0.507[b]	35.70 ± 0.840[b]	36.78 ± 0.295[a]	36.76 ± 0.590[a]	0.018
BWG 0-2 weeks	27.78 ± 0.311	27.74 ± 0.428	28.22 ± 0.192	28.20 ± 0.418	0.076

Means in the same row bearing different letters are significantly different (P≤0.05).
BWG: Body weight gain

Table 4.Effect of dietary supplementation with different levels of *Dunaliella salina* on feed intake of Pekin ducklings

Items	Control	*Dunaliella salina*/kg of duck diet			Sig.
		0.5 g	1.0 g	1.5 g	
FI 0-1 week	26.50 ± 1.017	27.88 ± 1.023	27.02 ± 1.143	26.48 ± 1.228	0.196
FI 1-2 weeks	60.88 ± 2.667	62.80 ± 2.310	61.38 ± 2.722	61.84 ± 3.976	0.773
FI 0-2 week	43.66 ± 1.837	45.34 ± 1.670	44.20 ± 1.910	44.14 ± 2.500	0.605

FI: Feed intake.

Table 5. Effect of dietary supplementation with different levels of *Dunaliella salina* on feed conversion ratio of Pekin ducklings.

Items	Control	*Dunaliella salina*/kg of duck diet			Sig.
		0.5 g	1.0 g	1.5 g	
FCR 0-1 week	1.348 ± 0.038	1.406 ± 0.052	1.372 ± 0.037	1.346 ± 0.046	0.147
FCR 1-2 weeks	1.694 ± 0.054	1.758 ± 0.053	1.670 ± 0.073	1.682 ± 0.080	0.197
FCR 0-2 weeks	1.572 ± 0.051	1.634 ± 0.055	1.568 ± 0.059	1.566 ± 0.067	0.230

FCR: Feed conversion ratio.

DISCUSSION

Our findings suggest that while higher levels of *D. salina* may numerically improve growth performance, the changes were not significant under the conditions of this study. These observations align with previous reports indicating that while *D. salina* is rich in bioactive compounds such as β-carotene, its effects on growth performance may not always reach statistical significance, especially under optimal management conditions. For example, **El-Baz *et al*. (2022)** reported that dietary *D. salina* supplementation in broilers improved live body weight and antioxidant capacity, though the improvements in performance metrics were sometimes non-significant. Similarly, **Gouveia *et al*. (2007)** noted that microalgae could improve the nutritional quality of feed but may not always yield measurable growth benefits. Similar outcomes were noted by **Mohamed *et al*. (2025)**, where dietary supplementation with a *D. salina* and *Arthrospira platensis* mixture at higher levels (1.0 g/kg diet) did numerically enhance live body weight in quail.

The BWG of ducks in the current study was enhanced at higher levels of *D. salina* (1.0 and 1.5 g/kg diet) during the early growing period, particularly after the first week. This suggests that the physiological benefits of *D. salina* may be more pronounced after the initial adaptation period. During the first week of life, the digestive and immune systems of young birds are still developing, and the full benefits of bioactive feed additives may be delayed. These findings align with **Mohamed *et al*. (2025)**, who reported that supplementation with 0.5–1.0 g/kg *D. salina* and *A. platensis* significantly increased body weight gain in quails from weeks 1 to 5. The same authors attributed these improvements to improved nutrient digestibility and gut health due to microalgae's antioxidant and anti-inflammatory properties. **Safdar *et al*. (2019)** emphasized the immunomodulatory and gut health-promoting properties of carotenoid-rich additives, which may lead to performance enhancement during the second and third weeks of age. Likewise, **Abdelnour *et al*. (2019)** reported gradual improvements in growth and immunity in broilers fed diets enriched with microalgae, especially after the first week of feeding.

The present work results suggest that the inclusion of *D. salina* at levels up to 1.5 g/kg in the diet does not significantly affect feed consumption in ducks during the early growth stage. These results imply that *D. salina* does not act as a strong appetite stimulant or feed efficiency enhancer in young ducks. While its antioxidant and health-promoting properties are well documented, the direct impact on feed utilization metrics such as FCR may require synergistic use with other performance enhancers or under challenging environmental conditions. **Spolaore *et al*. (2006)** concluded that microalgae primarily contribute to animal health and oxidative stability, with limited direct effects on feed conversion. **Ghasemi *et al*. (2014)** also reported that supplementing broiler diets with *Spirulina platensis* did not significantly influence FCR under non-stressful conditions. The lack of significant effects on feed intake and FCR is supported by **Mohamed *et al*. (2025)**, who observed non-significant changes in feed intake across different microalgae inclusion levels.

CONCLUSION

Despite the absence of significant effects of *D. salina* supplementation on live body weight, feed intake, and feed conversion ratio during the early growth phase (0–2 weeks of age), the observed significant improvement in body weight gain during the second week (1–2 weeks) indicates a potential onset of beneficial effects. This finding may suggest that the influence of *D. salina* becomes more pronounced in subsequent growth stages, warranting further investigation into its long-term impact on the performance of growing Pekin ducks.

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تأثير الإضافة الغذائية بالدونـاليلا سالينا على أداء النمو المبكر لصغار البط البكيني

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هدفنا في هذه التجربة إلى دراسة ما إذا كانت المستويات المختلفة من *Dunaliella salina* يمكن أن تؤثر على أداء النمو المبكر للبط البكيني خلال الفترة من عمر يوم حتى أسبوعين، حيث تم توزيع 200 طائر بط بكيني سليم بعمر يوم واحد عشوائيًا على أربع مجموعات تجريبية، واحتوت كل مجموعة على 5 مكررات، بكل مكرر 10 طيور، وقد غُذيت المجموعة الأولى على العليقة القياسية بدون أي إضافة، بينما غُذيت المجموعات الثانية والثالثة والرابعة على نفس العليقة مضافًا إليها 0.5، 1.0، و1.5 جم من *D. salina* لكل كجم علف على التوالي.

أظهرت البيانات عدم وجود تأثير معنوي للإضافة الغذائية لـ *D. salina* على وزن الجسم الحي خلال الأسبوع الأول (P = 0.926) والثاني (P = 0.232) من العمر، كما لم تتأثر الزيادة الوزنية (BWG) معنويًا بالمعاملات الغذائية خلال الفترتين 0-1 أسبوع (P = 0.701) و0-2 أسبوع(P = 0.076) ، ومن ناحية أخرى خلال الفترة من 1 إلى 2 أسبوع، أظهرت الطيور المغذاة على 1.0 و1.5 جم *D. salina* لكل كجم علف زيادة وزنية أعلى معنويًا (P = 0.018) مقارنةً بمجموعة الكنترول، ولم تؤثر الإضافة الغذائية لـ *D. salina* بشكل معنوي على كمية العلف المستهلك (FI) خلال الفترات التجريبية من 0-1(P = 0.196) و 1-2(P = 0.773) ، و0-2 أسبوع (P = 0.605) من العمر، كما لم تتأثر نسبة التحويل الغذائي معنويًا بإضافة *D. salina* بمستوياتها المختلفة خلال الفترات 0-1(P = 0.147) ، 1-2 (P = 0.197، و0-2 أسبوع.(P = 0.230)

تشير هذه النتائج إلى أن المستويات العالية من *D. salina* قد تُحسّن أداء النمو المبكر خلال أول أسبوعين من العمر، مع تأثير محدود على كمية العلف المستهلك ونسبة التحويل الغذائي خلال هذه الفترة.

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