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CONSEQUENCES OF ADDING BETAINE IN DUCKLINGS' DIETS ON PERFORMANCE DURING THE FIRST TWO WEEKS OF AGE

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ABSTRACT: This study was designed to evaluate the effects of dietary betaine supplementation at two levels (1.5 and 2.0 g/kg diet) on growth performance parameters of growing ducks during the first two weeks of age. A total of 150 healthy one- day-old Pekin ducks were randomly distributed into 3 experimental groups. Each group contained 5 replicates with 10 birds each. The first group received the standard diet with no supplementation, while the 2nd and 3rd groups received the standard diet supplemented with 1.5 and 2.0 g betaine per kg diet, respectively. The results showed that the live body weight (LBW) at the end of the first week was not significantly (P = 0.643) different among treatment groups. However, by the end of the second week, birds fed 2.0 g/kg betaine exhibited significantly (P = 0.039) higher LBW compared to the control group, with the 1.5 g/kg group showing intermediate values. Daily body weight gain (DBWG) during the first week was not affected (P = 0.361) by betaine supplementation. In contrast, during the second week (1–2 weeks), the 2.0 g/kg betaine group recorded the highest DBWG, which was significantly (P = 0.027) higher than the control group. Similarly, over the entire 0–2-week period, both betaine-treated groups had significantly greater (P = 0.029) DBWG compared to the control. Dietary betaine had no significant influence on daily feed intake (DFI) during 0-1 (P = 0. 200), 1-2 (P = 0. 400), and 0-2 (P = 0. 332) weeks of age. However, feed conversion ratio (FCR) was significantly improved with betaine supplementation, particularly at 2.0 g/kg. While no significant differences were found during the first week (P = 0.232), the 2.0 g/kg group showed a significantly better FCR during the second week and the overall period compared to the control group (P = 0.025 and 0.048, respectively). In summary, dietary betaine, especially at 2.0 g/kg, enhanced growth performance and feed efficiency without affecting feed intake, suggesting its potential benefit in improving productivity of ducklings during the early growth phase.

Key words: Ducklings; Betaine; Early growth performance

INTRODUCTION

With the rising demand for poultry meat, intensive farming practices have been widely adopted to maximize production efficiency. However, these practices can lead to several challenges, including compromised animal welfare, diminished meat quality, and altered flavor profiles **(Petracci *et al*., 2009; Maznouk, 2025)**. In recent years, there has been a growing interest in utilizing natural plant extracts to improve animal health and productivity **(Mahmoud *et al*., 2025)**. Betaine, a trimethyl derivative of glycine, is naturally present in various plants, such as alfalfa meal, wheat and sugar beet **(Chendrimada *et al*., 2002)**. As part of broader nutritional strategies aimed at enhancing poultry meat quality, betaine has gained attention for its physiological and nutritional benefits **(Dong *et al*., 2020)**. As a methyl donor, betaine contributes to osmoregulation, antioxidant defense and nutrient metabolism in poultry **(Eklund *et al*., 2005; Alirezaei *et al*., 2012; Attia *et al*., 2018)**.

Early research on betaine in poultry nutrition primarily focused on its role in preventing perosis and promoting growth. Betaine

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compound is a by-product of sugar beet processing and is also referred to as "glycine betaine" or "trimethylglycine". The two most common forms of betaine include betaine hydrochloride ($C_5H_{12}ClNO_2$) and anhydrous betaine ($C_5H_{11}NO_2$). It is highly water-soluble and can be incorporated into poultry rations as a liquid supplement, a dry powder, or a crystalline powder dissolved in drinking water. Studies have demonstrated that supplemental betaine positively influences growth performance, muscle yield, lipid metabolism, and immune function **(Attia *et al.*, 2009; Akhavan-Salamat and Ghasemi, 2016)**. Additionally, betaine has been identified as a lipotropic agent that facilitates fat mobilization from the liver and promotes lipid turnover within the body **(Saunderson and Mackinlay, 1990)**. It has also been utilized in low-crude protein diets with a high metabolizable energy-to-protein ratio to optimize poultry nutrition **(Ghasemi and Nari, 2020)**. Betaine's osmoregulatory function is crucial for maintaining intestinal enzyme stability and cellular protein integrity under environmental stressors, ultimately leading to improved poultry performance **(Ratriyanto *et al.*, 2010)**. Furthermore, betaine has been implicated in protecting against acute and chronic liver dysfunctions by mitigating oxidative stress at the mitochondrial level and modulating satellite cell activity. Its regulatory effects extend beyond liver health, influencing immune responses, cardiovascular function, nervous system regulation, and renal metabolism **(Kidd *et al.*, 1997; Sakomura *et al.*, 2013)**. Given these multifaceted benefits, betaine continues to be widely explored as a valuable feed additive in modern poultry nutrition. Limited studies have addressed its potential as a functional feed additive during early life stage in poultry, particularly in ducks. Given its biological activity, it is hypothesized that betaine supplementation may positively influence growth performance during the early life stage of Pekin ducklings. Therefore, the present study aims to investigate the effects of dietary betaine supplementation on early growth performance of Pekin ducklings in terms of LBW, BWG, FI and FCR.

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 2nd, 3rd, and 4th 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 daily body weight gain (DBWG)

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. Daily body weight gain (g/day) was calculated by subtracting the average live body weight of each replicate between two successive weights

(DBWG 0-1 and DBWG 1-2). Also, body weight gain was calculated for the whole period (DBWG 0-2) by subtracting the average initial live body weight (LBW 0) from the average final live body weight (LBW 2) of each replicate.

Daily feed intake (DFI) 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 DFI per chick per (DFI 0-1, 1-2, and 0-2). 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: $\mathbf{Y_{ij} = \mu + T_i + e_{ij}}$

Where:

$\mathbf{Y_{ij}}$ = An observation.

$\boldsymbol{\mu}$ = Overall mean.

$\mathbf{T_i}$ = The fixed effect of dietary betaine supplementation.

$\mathbf{e_{ij}}$ = 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)

Table 2 illustrates the effects of different levels of dietary betaine (1.5 and 2 g/kg diet) on the LBW of ducklings at three time points: post-hatch weigh (initial weight), first week LBW, and second week LBW. At the beginning of the experiment, there were no significant differences among the groups ($P = 0.918$), indicating that all birds started with comparable initial body weights. Similarly, at the end of the first week of age, no statistically significant differences were observed ($P = 0.643$). However, at the end of the second week of age, a significant difference ($P = 0.039$) was detected. Birds supplemented with 2 g/kg betaine achieved the highest final body weight (454.0 ± 19.89 g), which was significantly greater than the control group (424.1 ± 12.62 g). The 1.5 g/kg betaine group (444.7 ± 16.05 g) showed an intermediate response, not significantly different from either the control or the 2 g/kg group. These results suggest that higher levels of betaine, particularly at 2 g/kg, may enhance LBW during the early stages of growth.

Body Weight Gain (DBWG)

Table 3 presents the impact of dietary betaine supplementation (1.5 and 2.0 g/kg diet) on DBWG of ducklings during the first two weeks of age. During the first week (0–1 week), no significant differences were observed among the groups ($P = 0.361$), indicating that betaine had no effect on weight gain at this early stage. However, during the second week (1–2 weeks), a significant difference was detected ($P = 0.027$), where ducks receiving 2.0 g/kg betaine showed the highest DBWG (37.70 ± 2.535 g/day), significantly surpassing the control group (33.38 ± 1.766 g/day), while the 1.5 g/kg group (36.16 ± 2.223 g/day) showed intermediate values. Similarly, for the overall period (0–2 weeks), the 2.0 g/kg betaine group recorded the highest average DBWG (29.06 ± 1.348 g/day), followed by the 1.5 g/kg group (28.40 ± 1.084 g/day), both of which were significantly higher ($P = 0.029$) than the control group (26.90 ± 0.894 g/day).

Daily Feed Intake (DFI)

Table 4 demonstrates the effects of dietary betaine supplementation (1.5 and 2.0 g/kg diet) on the DFI of ducklings during the first two weeks of age. Across all measured intervals, 0–1 week, 1–2 weeks, and the entire 0–2-week period, no statistically significant differences were found among the treatment groups ($P > 0.05$). During the first week ($P = 0.200$), DFI ranged from 26.92 ± 1.033 g/day in the control group to 28.24 ± 1.026 g/day in the 1.5 g/kg betaine group. Similarly, in the second week, DFI values varied slightly among groups but remained statistically ($P = 0.400$) comparable, with values of 61.28 ± 2.487, 63.18 ± 2.268, and 61.10 ± 2.966 g/day for control, 1.5 g/kg, and 2.0 g/kg groups, respectively. Over the entire 0–2-week period, DFI also showed no significant differences ($P = 0.332$).

Feed Conversion Ratio (FCR)

Table 5 illustrates the effects of dietary betaine supplementation (1.5 and 2.0 g/kg diet) on the feed conversion ratio (FCR) of ducklings during the first two weeks of age. In the first week (0–1 week), no significant ($P = 0.232$) differences in FCR were observed among the groups. However, during the second week (1–2 weeks), a significant ($P = 0.025$) improvement in FCR was noted. Ducks receiving 2.0 g betaine/kg diet achieved the most efficient feed conversion (1.623 ± 0.099), significantly better than the control group (1.841 ± 0.139), while the 1.5 g/kg group (1.750 ± 0.076) showed intermediate values. Similarly, over the entire experimental period (0–2-week period), the FCR was significantly improved with increasing betaine levels ($P = 0.048$). The 2.0 g/kg group showing the best FCR (1.525 ± 0.068), followed by the 1.5 g/kg group (1.611 ± 0.040), both of which were superior to the control (1.641 ± 0.087).

DISCUSSION

The present work results suggest that the inclusion of betaine at levels up to 2 g/kg in the diet did not significantly affect DFI of ducklings during the early growth stage. These results imply that betaine does not act as a strong appetite stimulant in young ducks. While its beneficial effects as an extracellular osmolyte, a methyl donor, and its Osmo protective property and health-promoting properties may have a direct impact on feed utilization metrics such as FCR. The present results suggest that betaine supplementation, particularly at 2.0 g/kg, enhances FCR in growing ducks during the first two weeks of age, particularly during the second one. The improved feed efficiency in response to betaine might also, associated with its Osmo protective feature, which protects the intestinal epithelia from any osmotic disorders (**Shakeri, *et al*., 2018**) and improves the digestibility of crude fiber, crude protein, dry matter, and non-nitrogen fiber extract which in turn helps the expansion of intestinal mucosa (**El-Husseiny, *et al*., 2007**). In a recent study conducted by **Elmahdy *et al*. (2025),** FCR of broiler chicks was significantly improved durng the second week of age in response to adding betaine betaine to their diet at levels of 2 and 2.5 g /kg diet, while FI was not affected due to dietary spplementation of betaine. Also, **Wen *et al*. (2021)** found that dietary betaine supplementation at 500 or 1,000 mg/kg in broilers that fed mold-contaminated corn-based diet improved BWG and FCR. Betaine participates in the development and protection of the morphological features of the intestinal epithelium, improving the nutritional efficiency of broiler chickens during times of osmotic disturbance caused by heat stress **(Hamidi *et al*., 2010; Sakomura *et al*., 2013)**. **Klasing *et al*. (2002)** stated that the inclusion of betaine (0.05 or 0.1%) heightened the duodenal villus length and enhanced the osmolality. In contrast, **Park and Kim (2019)** found that dietary betaine supplementation in broiler diets at level of 0.12% had no significant ($P > 0.05$) effect on feed utilization parameters (FI and FCR) during 1-42 days of age.

CONCLUSION

Based on the obtained results, dietary supplementation with betaine, particularly at a level of 2.0 g/kg diet, positively influenced growth performance and feed utilization of Pekin ducklings during the first two weeks of age. While betaine had no significant effect on growth or daily feed intake during the first week, it significantly improved LBW and

DBWG during the second week, as well as overall weight gain across the two-week period. Furthermore, betaine supplementation led to a significant improvement in FCR, indicating enhanced nutrient utilization. These findings suggest that incorporating betaine, especially at 2.0 g/kg, into the diets of Pekin ducklings can be an effective nutritional strategy to support optimal growth and improve feed utilization during the early growing phase.

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

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. Consequences of adding betaine in Pekin ducklings' diets on live body weight during the first 2 weeks of age

Items	Control	Dietary betaine levels (g/kg diet)		Sig.
		1.5 g	2.0 g	
Post-hatch LBW	47.60 ± 1.483	47.24 ± 1.498	47.38 ± 1.137	0.918
First week LBW	190.4 ± 2.913	191.6 ± 1.932	189.9 ± 3.444	0.643
Second week LBW	424.1 ± 12.62^{b}	444.7 ± 16.05^{ab}	454.0 ± 19.89^{a}	0.039

LBW: Live body weight.

Means in the same row bearing different letters are significantly different (P≤0.05).

Table 3. Consequences of adding betaine in Pekin ducklings' diets on daily body weight gain during the first 2 weeks of age

Items	Control	Dietary betaine levels (g/kg diet)		Sig.
		1.5 g	2.0 g	
0–1-week DBWG	20.40 ± 0.324	20.62 ± 0.228	20.36 ± 0.329	0.361
1–2-weeks DBWG	33.38 ± 1.766^{b}	36.16 ± 2.223^{ab}	37.70 ± 2.535^{a}	0.027
0–2-weeks DBWG	26.90 ± 0.894^{b}	28.40 ± 1.084^{ab}	29.06 ± 1.348^{a}	0.029

DBWG: Daily body weight gain.

Means in the same row bearing different letters are significantly different (P≤0.05).

Table 4. Consequences of adding betaine in Pekin ducklings' diets on daily feed intake during the first 2 weeks of age

Items	Control	Dietary betaine levels (g/kg diet)		Sig.
		1.5 g	2.0 g	
0–1-week DFI	26.92 ± 1.033	28.24 ± 1.026	27.44 ± 1.216	0.200
1–2-weeks DFI	61.28 ± 2.487	63.18 ± 2.268	61.10 ± 2.966	0.400
0–2-weeks DFI	44.12 ± 1.734	45.74 ± 1.609	44.28 ± 2.071	0.332

DFI: Daily Feed intake.

Table 5. Consequences of adding betaine in Pekin ducklings' diets on feed conversion ratio during the first 2 weeks of age

Items	Control	Dietary betaine levels (g/kg diet)		Sig.
		1.5 g	2.0 g	
0–1-week FCR	1.319 ± 0.044	1.370 ± 0.049	1.347 ± 0.038	0.232
1–2-weeks FCR	1.841 ± 0.139^{b}	1.750 ± 0.076^{ab}	1.623 ± 0.099^{a}	0.025
0–2-weeks FCR	1.641 ± 0.087^{b}	1.611 ± 0.040^{ab}	1.525 ± 0.068^{a}	0.048

FCR: Feed conversion ratio.

Means in the same row bearing different letters are significantly different (P≤0.05).

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تأثيرات إضافة البيتاين إلى علائق صغار البط على الأداء خلال أول أسبوعين من العمر

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تم تصميم هذه الدراسة لتقييم تأثير إضافة البيتاين إلى علائق صغار البط بمستويين (1.5 و2.0 جم/كجم عليقة) على مؤشرات الأداء خلال أول أسبوعين من العمر، حيث تم استخدام 150 طائر بط بكيني سليم بعمر يوم واحد، ووزعت عشوائيًا على ثلاث مجموعات تجريبية، واحتوت كل مجموعة على 5 مكررات، وكل مكررة ضمت 10 طيور، وقد تغذت المجموعة الأولى العليقة القياسية بدون إضافة، بينما تغذت المجموعتان الثانية والثالثة العليقة القياسية مضافًا إليها 1.5 و2.0 جم بيتاين لكل كجم عليقة، على التوالي، وقد أظهرت النتائج أن الوزن الحي في نهاية الأسبوع الأول لم يختلف بشكل معنوي (P = 0.643) بين المجموعات التجريبية، ومع ذلك ففي نهاية الأسبوع الثاني سجلت الطيور التي تلقت 2.0 جم بيتاين/كجم عليقة وزنًا حيًا أعلى بشكل معنوي (P = 0.039)مقارنةً بالمجموعة الضابطة، وكانت مجموعة 1.5 جم/كجم ذات قيم وسطية بين المجموعات، ولم تتأثر الزيادة اليومية في وزن الجسم خلال الأسبوع الأول بإضافة البيتاين (P = 0.361) ، بينما سجلت مجموعة 2.0 جم/كجم خلال الأسبوع الثاني أعلى وزن جسم مكتسب بفروق معنوية (P = 0.027) مقارنةً بالمجموعة الضابطة، وبالمثل، خلال كامل الفترة من 0 إلى 2 أسبوع، أظهرت المجموعتان المعاملتان بالبيتاين زيادات معنوية (P = 0.029) في زن الجسم المكتسب اليومي مقارنةً بالمجموعة الضابطة، من ناحية أخرى، لم تؤثر إضافة البيتاين بشكل معنوي على الاستهلاك اليومي للعلف خلال فترات 0–1(P = 0.200) ، و1–2(P = 0.400) ، و0–2 أسبوع (P = 0.332) ، ومع ذلك، أظهر معامل التحويل الغذائي تحسنًا معنويًا مع إضافة البيتاين وخصوصًا عند مستوى 2.0 جم/كجم عليقة، ففي حين لم تُلاحظ فروق معنوية خلال الأسبوع الأول(P = 0.232) ، سجلت مجموعة 2.0 جم/كجم عليقة أفضل معامل تحويل غذائي خلال الأسبوع الثاني وكامل الفترة مقارنةً بالمجموعة الضابطة (P = 0.025 and 0.048) على التوالي، وباختصار، حسنت إضافة البيتاين إلى العليقة، خاصة عند مستوى 2.0 جم/كجم من الأداء الإنتاجي وكفاءة التحويل الغذائي دون التأثير على استهلاك العلف، مما يشير إلى فائدته المحتملة في دعم إنتاجية بط التسمين خلال مرحلة النمو المبكرة.

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