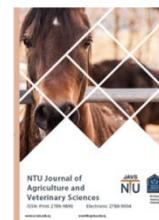




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## Use of Betaine and Glycine as Nutritional Supplements in Laying Hens' Diets and their Effect on Production Performance

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### ABSTRACT

The study was conducted in the laying hens field of the Animal Production Department - College of Agriculture and Forestry / University of Mosul, in a semi-closed hall with floor-based rearing of and 216 local (Mezo) laying hens were used for the purpose of the study in the production stage from the beginning of week 44 until the end of week 54week, The ration provided to the hens was uniform in energy (2865 kcal/kg) and protein (17%), with betaine and glycine supplementation to the treatment rations, where the treatments were as follows:

T1: Control

T2: Use of betaine 2.4 gm/kg ration

T3: Use of glycine 2.4 gm/kg ration

T4: Use of betaine 1.2 gm + glycine 1.2 gm/kg ration

The experimental period lasted 11 weeks, during which data on production indicators were taken and statistically analyzed at a significance level ( $P \leq 0.05$ ). The results were as follows:

There was a significant increase in the mass of eggs produced and the egg production rate%, an improvement in the feed conversion ratio, and a decrease in the feed consumption of hens in the treatments that contained betaine and glycine or both together compared to the control treatment, while it was found that the number and weight of eggs produced were not significantly affected.



## Introduction

Poultry projects are among the most widespread in the field of animal production, providing a source of animal protein in many countries around the world [1], providing nutritionally valuable products in the form of meat and eggs as a source of protein and essential nutrients [2]. The human nutritional requirement for animal protein ranges from approximately 75-80 grams [3], and it is well known that eggs are an animal product with good nutritional value. A 60-gram egg provides approximately 6.5 grams of protein, which represents 14.4% of an adult's protein requirement, represented by amino acids. It is also a source of fats [4, 5], and is rich in vitamins and minerals such as calcium, iron, and phosphorus [6,7,8]. This has prompted organizations such as the World Health Organization (WHO), the Spanish Heart Foundation (FEC), and the European Food Information Council (EUFIC) to recommend regular egg consumption as part of a healthy diet [9], which has led to increased attention to its production and quality.

As the productive age of laying hens advances, egg production and quality decline due to the continuous physiological changes of the digestive and reproductive systems, which constitute a group of different physiological processes that significantly affect poultry production and health, including the ovary and oviduct, whose tissues are susceptible to aging, characterized by granulosa cell death, chronic inflammatory activity, oxidative stress, abnormal hormonal response, decreased intestinal absorption, or metabolic imbalance [10,11,12]. In addition, the methionine content of feed is a determinant of egg production and weight gain. This increases the bird's requirement for this amino acid, as it is involved in metabolic processes that require the removal of its methyl group. Recently, researchers have gathered information on the effect of the amino acids betaine and glycine as essential nutritional supplements. These supplements have been incorporated into poultry feeds to improve production and feed efficiency, in line with World Health Organization guidelines to exclude antibiotics and chemical drugs that are deposited in animal tissues. High-yielding laying hens require feeds with high specifications, especially in the late stages of production, when lipid metabolism and visceral fat deposition increase, affecting the performance of laying hens [12, 13].

Research results have shown that betaine and glycine play important physiological roles in the body of living organisms. They are methionine supplements and enhance its presence [14,15]. Betaine and glycine enhance the presence of

methionine, thus increasing its abundance as an essential amino acid in nutrition that the body needs for growth and production due to the bird's inability to synthesize it [16]. Betaine also improves the productive performance of laying hens [17],

improves feed conversion ratio by enhancing the physiological functions of the intestine and thus increasing the rate of digestion and absorption [18, 19], contributes to eliminating intestinal infections, reducing pathogenic microbes, and maintaining immune balance [20,21], and it has been proven that betaine alleviates the effect of heat stress in birds and helps regulate body temperature [22].

These management techniques in exploiting nutrition, such as adding feed supplements of amino acids, maintain the production level of the flock for an additional production period, especially production in the advanced production age. This study was conducted to identify the importance of betaine and glycine in raising the production performance of laying hens, and to study their effect on egg quality.

## Materials and Methods

The study was conducted in the laying hens field of the Animal Production Department - College of Agriculture and Forestry / University of Mosul, for the period from 10/8/2024 to 3/11/2024 and 216 local Mezo laying hens were used for the purpose of the study in the production stage from the beginning of week 44 until the end of week 54, and the treatments included preparing the feed with the amino acids betaine and glycine as follows:

T1: Control

T2 :Use of betaine 2-4 gm/kg ration

T3 :Use of glycine 2.4 gm/kg ration

T4: Use of betaine 1.2 gm + glycine 1.2 gm/kg ration

A semi-closed production hall was used for laying hens, and the breeding was on a floor with a plastic mesh mattress. The hall was divided into 12 rooms, each of which represented a replicate with a breeding density of 18 hens/pen , equipped with the necessary supplies of feeders, drinking water, and nests. All appropriate environmental conditions were taken into account, as the temperature was (18-22) C, taking into account humidity, ventilation, and lighting, and the availability of veterinary unit supervision throughout the experimental period in the fields in the Animal Production Department.

The ration materials were purchased from the local market, crushed, thoroughly mixed, and formulated according to the recommendations of the National Rural Development Organization [23]. The feed provided to hens with betaine and glycine added to the treatment rations. The study period lasted 11 weeks, during which weekly data on production indicators for Mezo chickens were collected, such as the number, weight, and mass of eggs produced. The production rate (HDP) was calculated. The remaining feed intake was calculated to determine the amount of feed consumed, noting that the feed provided was in specific quantities to determine the effect of adding betaine and glycine on feed consumption. The feed conversion ratio was also calculated. Live weights

were monitored to determine the extent of change in live body weight and its impact on the supplementation.

**Table 1.** shows the percentages of ration components

Feed Component	Its Percentage In The Feed(%)
Yellow Corn	47.5
Soybean meal	24
Wheat	15.5
Sunflower oil	1
Premix	2.5
Mono calcium phosphate	1
Limestone	8.250
Salt	0.250
Total	100
Chemical Composition	
M.E (kcal/kg feed)	2865.65
Crude Protein (%)	16.89
Crude Fiber (%)	3.08
Calcium (%)	0.72
Methionine	0.41
Methionine + Cysteine (%)	0.7
Lysine (%)	0.9

Calculated according to (N.R.C, 1994)

Statistical analysis: A complete randomized design (CRD) was used. data were analyzed using SAS [24], Duncan multiplies Rang was applied to determine differences between treatments [25] significant range ( $P \leq 0.05$ ).

## Results and discussion

### The use of betaine and glycine in ration and their effect on the number of eggs produced (egg/hen/week):

Table (2) shows no significant effect of using 2.4 gm betaine, 2.4 gm glycine, and 2.4 gm betaine + glycine/kg in the ration on number of eggs production (egg/hen/week) compared with control during the production weeks from the beginning of week 44 until the end of week 54. These results agreed with [26], as he did not find a significant effect of adding 0.5% betaine to the laying ration at age of 38 weeks and for four weeks period. However, they differed with [27,28,29], and also with [30], as they found that number of eggs production increases significantly by adding different percentages of betaine.

### The use of betaine and glycine in ration and their effect on the weight of eggs produced (egg/hen/week):

Table (3) shows that there was no significant differences ( $P \leq 0.05$ ) in average egg weight of Mezo hens (gm/hens) during the production weeks from the beginning of week 44 until the end of week 54 between the second, third and fourth treatments compared to the control treatment.

These results were agreed with [22] who did not find that adding 0.5% betaine to rations had a significant effect on weight of egg production by both the Ice Brown and Lohmann strains compared to the control, and also with [31] when they use (0.05 and 0.10)% of glycine, as well as [30], where he stated that weight of the egg was not affected by using (0.0, 0.1, 0.2)% glycine to the ration for a production period of (28-40) weeks compared to control, as well as with [32] by using glycine at a rate of (0.341 and 0.683)%, and also [33] indicated that there was no significant effect in supplementation glycine at a rate of 0.03% compared to control in average egg weight of hens aged 70-82 weeks.

While these results differed from [28] as well as [14,4,15,34] they found that weight of the production eggs increased significantly by using different percentages of glycine to the laying hens' ration, this also did not agree with the researcher [34] who observed a decrease egg weight when the laying hens were fed a ration containing betaine compared to control, and [35] observed that egg weight increased when using (0.025, 0.05, 0.075, 0.1, 0.125)% glycine in the diets compared to control for the production period (71-74) weeks.

### Use of betaine and glycine in the ration and their effect on egg mass (g/hen/week):

Table (4) Although there were no significant differences between treatments in egg mass during weeks (44, 45, and 46) of production, egg mass increased significantly in all subsequent weeks from 47 to 54 week in the betaine and glycine addition treatments (second, third, and fourth) compared to control treatment. The average egg mass for the total production period also increased with egg mass reaching (349.98, 356.45, and 362.27) gm/hen/week, compared to the control treatment, which reached (319.59) gm/hen/week.

The lack of effect of betaine and glycine on egg mass during the first weeks of production, while their effect appeared in subsequent weeks, was due to their cumulative effect on these traits.

The reason for the significant improvement in egg mass is the betaine and glycine increase the availability of methionine, by granting a methyl group, enables it to convert homocysteine to methionine [36], which increases the need for protein synthesis, thus increasing its availability for production and growth [37, 38,39]. It improves the performance of laying hens [40,41, 42,17]. And [43] reported that the increase in egg mass was due to the improved lysine content of the ration as a result of adding betaine to the ration. This improvement also included the use of glycine, an amino acid similar to betaine, in the synthesis of some amino acids. It is also a precursor for the synthesis of betaine, purine,

and glutathione. It is also considered a structural unit in the formation of elastin, collagen, and keratin [43]. This was reflected in egg weight. The best egg mass deposition occurred in the fourth treatment, which included the combined addition of betaine and glycine, demonstrating the synergistic effect of the two compounds, which worked to improve this character.

These results agreed with the researchers [28], as they found that betaine had a significant effect when added (0.5, 1.0, 1.5)% compared to control and for age periods 37-48 weeks, as the egg mass increased significantly in the addition treatments compared to control. While it differed with [44] who stated that egg mass decreased significantly by adding 1000 mg betaine/kg ration during the production period (32-36) weeks in dual-purpose chickens, the researcher [27] did not find a significant effect of adding betaine (0.7, 1.5) gm/kg on egg mass for hens at the age of 20 weeks and for a production period of 23 days compared to control, and it also differed with [22] who did not find a significant effect of added betaine 0.5% on egg mass.

#### **The use of betaine and glycine in the ration and their effect on egg production rate % :**

Table (5) shows no significant differences ( $p \leq 0.05$ ) between treatments during the first two weeks (44 and 45). However, the egg production rate increased significantly during the subsequent productive age stages (45, 46, 47, 48, 49, 50, 51, 52, 53) weeks in the second, third, and fourth treatments compared to control. It is worth noting that the fourth treatment, which included betaine and glycine together, was the most egg-producing treatment. As a result of the total egg production from the beginning of week 44 until the end of week 54, it reached (79.63, 80.68, 88.83)% for the second, third, and fourth treatments, respectively, compared to the first treatment, which reached (74.68)%. There is an increase in production rate for the supplementation treatments, as it reached (106.36, 108.03 and 112.32) % compared to the control, which consider as 100% in the control treatment.

This is attributed to the fact that glycine enhanced the action of betaine, as it is considered the smallest molecule in the formation of betaine, which is dimethyl glycine, which is converted into betaine with the help of the enzyme betaine homocysteine methyltransferase (BHMT) [44,36,16]. Glycine also contributes to the formation of some amino acids such as purine, glutathione, elastin, collagen, and keratin [43]. Also, betaine and glycine together were able to provide the methyl group that would have been taken from methionine if they were not added to the diet, so there was an abundance of methionine, which took the direction of increasing production by increasing the rate of its utilization [41,44,16]. [17]

reported that betaine and glycine improve ovarian aging by affecting the genetic factor (EGR1) responsible for ATP6 [42]. Betaine also has a role in influencing the genetic gene (OCLN, CLDN-1) [29,46], This led to an improvement in the absorption rate and the utilization rate of nutrients, and this was reflected in the production of betaine and glycine treatments. Perhaps this improvement in production was due to the improvement in the health of the immune system and the health of the digestive system [46].

These results agreed with [42], who reported that egg production increased to 70% of the 64.3% average production rate when betaine was added at 1000 mg/kg compared to control diet over 32–36 weeks. [28] also reported that adding betaine significantly increased production compared to control diet [47], [29] supplemented rations with 3 and 6 g of betaine/kg of feed to 32-week-old chickens for 6 weeks and observed an increase in production. This was supported by the researchers [48,49]. In a study by the researcher [25], it was mentioned that the rate of egg production increased significantly by adding 3000 mg betaine/kg feed at different age periods and a total production period (29-41) days compared to the control treatment. Also, [50] noted a significant increase in a rate of egg production by 13.1% more than the control in the layer flock fed on ration containing (2000) mg betaine/kg feed.

While these results differed from [27] as he did not find that adding betaine (0.7, 1.5) gm/kg had a significant effect on the egg production rate compared to control for hens at the age of 20 weeks and for a production period of 23 days. Also, [17] did not find a significant effect on egg production by

added 0.5% betaine for a period of four weeks in the diet of laying hens for late stages of production. Also, [52] did not find that betaine to the diet at an amount of (0.0, 0.125, 0.250, 500) gm/ton did not affect in rate of egg production during a period of 12 weeks for the flock at age of 45 and 57 weeks. the researcher [36] did not find a significant effect using glycine (0.025, 0.05, 0.075, 0.1, 0.125)% on egg production for different production periods. Also, [32] when he added glycine (0.341 and 0.683)% compared to control during the rearing period (12) Week.

#### **Use of betaine and glycine in the ration and their effect on the amount of feed consumed (g/chicken/week).**

Table (6) shows that there are significant differences ( $P \leq 0.05$ ) between treatments, as the amount of feed consumed decreased significantly in week (44) for the second and fourth treatments compared to the control. The second and third treatments did not differ significantly compared to control and fourth treatments. In weeks (46 and 47), the amount of feed consumed decreased significantly in all betaine and

glycine addition treatments (second, third, and fourth) compared to the first treatment. In weeks (48, 52, and 54), the amount of feed consumed decreased significantly in the third and fourth treatments compared to the first and second treatments. The total feed intake during the entire study period of 44-54 weeks decreased in the treatment of adding 2.4 betaine, 2.4 glycine and 2.4 betaine + glycine compared to the control group, reaching (721.61, 710.18, 703.40, 733.47) gm/hens /week, respectively.

This decrease in the feed consumed by the treatments containing betaine and glycine is due to the abundance of amino acids in them compared to the control treatment, which provided the body with a greater amount of amino acids that were used in the synthesis of creatine, which supports the use of energy within cells and increases the content and activity of mitochondria [39] for the purpose of maintenance and production, which made the bird satisfied with a smaller amount of feed, and this is consistent with Table (4) regarding the weekly egg mass of one hen, which represents the real physical unit of production, and this was reflected in the feed conversion ratio (Table 7).

#### **Use of betaine and glycine in the ration and their effect on the feed conversion ratio (g feed/g eggs)**

Table (7) indicates an improvement in the feed conversion ratio in the feed preparation treatments with betaine and glycine compared to control group during all production weeks. The second, third, and fourth treatments (2.4 gm betaine, 2.4gm glycine,

2.4g betaine + glycine) decreased significantly compared to control treatment. The feed conversion ratio values in weeks (43, 48, 50, 51, 52, 53) were higher. During weeks 45, 46, and 48, the feed conversion ratio improved in the third and fourth treatments compared to the first and second treatments. In weeks 47 and 50, the feed conversion ratio improved in the fourth treatment, which used 2.4g betaine + glycine, compared to control treatment. The values reached (1.68, 2.19) and (1.88, 2.21) gm feed/gm eggs for the treatments and for the two weeks respectively.

From the table, we found that the conversion factor ratio as an average for the entire period improved in the treatments of adding 2.4 gm betaine, 2.4 gm glycine, and 2.4 g betaine + glycine, as its value decreased to (2.06, 1.99, and 1.94) gm feed/g egg compared to control treatment, which amounted to (2.51) gm feed/gm egg. The improvement in feed conversion is due to the improvement in intestinal health and function with the addition of nutritional supplements such as betaine and glycine [48]. They enhance the intestinal environment by increasing Bacteroidetes, which play a major role in the intestinal environment and intestinal function [53,54,55,56]. Betaine also acts as

an osmolyte solution that increases It helps intestinal cells retain water and supports their growth and activity, which increases the rate of digestion and absorption [57]. Betaine and glycine also improve the growth of villi by increasing their height, depth, and the ratio between them, which enhances the digestion and absorption processes, and this is reflected in the rate of utilization [58,59].

#### **The use of betaine and glycine in the ration and their effect on the change in live body weight:**

Table (8) indicates that use of betaine and glycine in the diets (2.4 gm betaine, 2.4 gm glycine, 2.4 g betaine and glycine) did not significantly affect the amount of change in live body weight (gm) compared to the control (live weight of the hens at the end of the experiment compared to its weight at the beginning of the experiment) after the hens were subjected to these treatments throughout the production weeks.

#### **Conclusion**

Use of betaine and glycine as nutritional supplements in the feed of laying hens in the late stages of production improved production indicators, provided support and enhanced the work of methionine, supplied the hens with acids, and raised the level of the digestive and reproductive systems by renewing tissues, which was reflected in production performance.

#### **Conflict of interest**

The researchers pledge that there is no conflict in writing the research with the interests of publishing this article.

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**Table 2.** Use of betaine and glycine in ration and their effect on number ht (egg/hen/week).

Age of hens\ week	number of egg weight (egg/hen/week).			
	T1 Control	T2 2.4 gm betaine	T3 2.4 gm glycine	T4 2.4gm betaine+glycine
44	4.98 ± 0.5 ab	4.94 ± 0.25 b	5.00 ± 0.21 ab	5.29 ± 0.34 a
45	5.10 ± 0.35 a	5.28 ± 0.43 a	5.52 ± 0.30 a	5.42 ± 0.13 a
46	5.35 ± 0.36 a	5.63 ± 0.42 a	5.59 ± 0.30 a	5.72 ± 0.13 a
47	5.30 ± 0.34 a	5.80 ± 0.35 a	5.61 ± 0.44 a	6.02 ± 0.14 a
48	5.20 ± 0.44 b	5.67 ± 0.35 ab	5.65 ± 0.05 ab	6.20 ± 0.05 a
49	5.28 ± 0.44 a	5.46 ± 0.05 a	5.54 ± 0.3 a	5.93 ± 0.31 a
50	5.31 ± 0.44 a	6.04 ± 0.43 a	5.67 ± 0.41 a	6.06 ± 0.16 a
51	5.23 ± 0.49 a	5.56 ± 0.28 a	5.56 ± 0.35 a	5.79 ± 0.05 a
52	4.79 ± 0.49 a	5.56 ± 0.28 a	5.56 ± 0.33 a	5.23 ± 0.15 a
53	5.15 ± 0.46 a	5.48 0.18 a	5.94 0.04 a	6.02 ± 0.21 a
54	5.27 ± 0.58 a	5.86 0.13 a	5.86 ± 0.13 a	6.11 ± 0.34 a

Different letters in a row indicate significant differences between means (P≤0.05) (mean ± S.E).

**Table 3.** Use of betaine and glycine in ration and their effect on average egg weight (gm/hen).

Age of hens\ week	Average egg weight g/hen			
	T1 Control	T2 2.4gm betaine	T3 2.4 gm glycine	T4 2.4gm betaine+ glycine
44	58.00 ± 1.4 a	59.65 ± 0.38 a	59.59 ± 0.22 a	58.60 ± 0.13 a
45	60.1 ± 0.35 b	61.25 ± 0.25 ab	62.06 ± 0.11 a	61.40 ± 0.44 ab
46	60.39 ± 0.12 a	60.81 ± 0.14 a	60.90 ± 0.11 a	61.07 ± 0.47 a
47	59.85 ± 0.34 a	60.16 ± 1.06 a	61.17 ± 0.34 a	62.76 ± 1.41 a
48	60.84 ± 0.33 a	61.25 ± 0.18 a	61.67 ± 0.55 a	62.07 ± 0.15 a
49	61.73 ± 1.44 a	64.48 ± 1.55a	61.37 ± 0.45 a	62.60 ± 1.77 a
50	61.10 ± 0.88 a	61.71 ± 0.33 a	61.33 ± 0.45 a	62.19 ± 1.22 a
51	63.40 ± 0.77 a	63.58 ± 0.90 a	63.56 ± 1.45 a	0.49 ± 64.28a
52	63.53 ± 0.5 a	63.88 ± 1.31 a	63.66 ± 2.8 a	64.44 ± 1.12 a
53	60.18 ± 2.1 b	1.09 ± 61.25ab	0.58 ± 62.06a	0.14 ± 61.04ab
54	0.05 ± 63.67a	0.26 ± 63.38a	0.78 ± 63.57a	0.84 ± 64.28a
55	61.17 ± 0.34 a	61.95 ± 0.55	61.85 ± 0.6 a	62.25 ± 0.87 a
54-44	61.17 ± 0.87 a	61.95 ± 0.29 a	61.85 ± 0.66 a	62.25 ± 0.93 a

Different letters in a row indicate significant differences between means (P≤0.05) (mean ± S.E).

**Table 4.** Use of betaine and glycine in feed and their effect on egg mass (gm/hen/week)

Age of hens\ week	egg mass (gm/hen/week)			
	T1 Control	T2 2.4 gm betaine	T3 2.4 gm glycine	T4 2.4gm betaine+glycine
44	288.98 ±15.33 b	294.71 ±15.4 ab	299.75 ±2.0 ab	310.27 ±10.59 a
45	306.92 ±16.82 a	19.76±323.41a	12.02±342.74a	10.01±332.78a
46	323.50 ±14.06 a	342.44 ±16.2 a	340.56 ±17.8 a	349.46 ±9.78 a
47	317.29 ±10.03 c	351.54 ±8.12 b	343.16 ±15.5 b	377.82 ±12.07 a
48	316.36 ±12.45 c	±347.2810.56 b	348.39 ± 10.6 b	388.04 ±10.55 a
49	325.93 ±6.7 b	353.81 ±15.54 a	341.12 ±10.11 a	371.13 ±±4.52 a
50	323.49 ±13.3 b	372.71 ±10.9 b	366.14 ±7.55 b	377.04 ±6.44 a
51	331.58 ±12.6 b	359.25 ±13.44 a	359.62 ±13.17 a	372.18 ±6.46 a
52	302.37 ±17.16 b	355.71 ±11.68 a	353.17 ±11.49 a	337.02 ±11.79 a
53	309.93 ±19.45 b	335.65 ±6.92 a	368.64 ±9.38 a	368.07 ±12.79 a
54	334.79 ±13.92 b	371.92 ±10.06 a	372.52 ±10.01a	392.25 ±6.03 a
44-54	319.59 ± 12.1b	349.9 ± 7.45 a	356.45± 9.81a	362.27±8.55 a

Different letters in a row indicate significant differences between means (P≤0.05) (mean ± S.E).

**Table 5.** Use of betaine and glycine in feed and their effect on egg production rate H.D.P%%

Age of hens\ week	egg production rate H.D.P%			
	T1 Control	T2 2.4 gm betaine	T3 2.4 gm glycine	T4 2.4gm betaine+glycine
44	71.16 ± 9.17 a	70.57 ±3.63 a	71.42 ±3.0 a	75.65 ±3.93 a
45	72.86 ± 4.12 a	75.40±3.74 a	78.83 ±3.25 a	73.80 ± 1.85 a
46	76.45 ±3.63 b	80.42 ± 2.96 a	79.89 ±2.72 a	81.75 ±4.00 a
47	75.71 ±2.17 b	82.80 ± 2.06 a	82.81 ±3.21 a	86.00 ±2.38 a
48	74.28 ± 3.45 b	81.6 ±3.70 b	80.71 ±1.69 b	88.62 ±1.70 a
49	75.43 ±1.65 b	78.00 ±1.83 a	79.14 ±2.32 a	84.65 ±1.12 a
50	75.86 ±1.92 b	86.30 ±3.00 a	86.20 ±4.00 a	86.60 ±2.02 a
51	74.70 ±1.99 b	79.45 ±4.02 a	79.46 ±3.23 a	82.73 ±3.08 a
52	72.27 ± 3.21 b	79.43 ±3.6 a	80.35 ±1.85 a	85.71 ±2.06 a
53	73.51 ±3.52 a	78.26 ±2.5 ab	84.81 ±1.38 a	86.00 ±3.02 a
54	75.29 ±1.22 b	83.62 ±3.73 a	83.71±1.93 a	87.19 ±3.73 a
44-54	74.68 ± 2.11 b	79.63 ±2.21a	80.68 ±1.66 a	88.83 ± 2.30 a
Treatment production % of control	100	106.63	108.03	112.32

Different letters in a row indicate significant differences between means (P≤0.05) (mean ± S.E).

**Table 6.** Use of betaine and glycine in feed and their effect on the amount of feed consumed (g/chicken/week)

Age of hens\ week	Feed consumption gm/hen/week			
	T1 Control	T2 2.4 gm betaine	T3 1.2 gm glycine	T4 2.4gm betaine+glycine
44	744.95±11.51 a	650.03±16.17 b	685.92±11.38 ab	613.05 ±13.47b
45	734.21 ±15.70 a	730.97 ±18.78a	734.52 ±10.47 a	731.55±18.78 a
46	12.06±752.22 a	749.41 ±9.31ab	13.49±743.27ab	738.06±15.32 b
47	695.14 ±10.33 a	661.18±10.17 b	663.59 ±10.31 b	668.13±14.44 b
48	763.33 ± 11.47 a	776.10±14.05 a	745.62 ± 11.97 b	756.83±11.49 b
49	726.83 ±12.50 a	711.46±16.67 a	707.55 ± 6.99 a	10.93±724.73a
50	715.05 ± 9.98 a	705.52±10.20 a	724.00 ±12.01 a	708.49 ±7.91 a
51	727.16 ±11.26 a	690.46 ± 6.81 b	664.35 ±13.51 b	669.7810.55±b
52	707.44 ±10.64 a	734.28±13.53 a	692.88 ±9.94 b	630.59± 13.28b
53	751.33 ±15.65 a	764.21±14.43 a	744.37 ±16.06 a	751.97 ±9.73 a
54	750.51±13.31ab	764.16±13.06 a	735.96 ±11.69 b	744.21 ±9.02 b
54-44	733.47 ±12.02 a	721.61± 10.55a	712.91 ±13.01 b	703.40 ±12.00b

Different letters in a row indicate significant differences between means (P≤0.05) (mean ± S.E).

**Table 7.** Use of betaine and glycine in feed and their effect on the feed conversion ratio (gm feed/gm eggs).

Age of hens\ week	feed conversion ratio (gm feed/gm eggs).			
	T1 Control	T2 2.4gm betaine	T3 2.4 gm glycine	T4 2.4gm betaine+ glycine
44	2.27 ± 0.35 a	2.26 ±0.22 b	2.31 ±0.13 b	1.99 ±0.89 b
45	2.39 ± 0.12 a	2.26 ±0.19 ab	2.31 ±0.13 b	2.14 ±0.07 b
46	2.35 ±0.019 a	2.18 ±0.17 ab	2.19 ±0.10 b	2.13 ±0.014 b
47	2.19 ±0.12 a	1.88 ±0.16 ab	1.93 ±0.12 ab	1.68 ± 0.02 b
48	2.41 ±0.11 a	2.23 ±0.01 ab	2.14 ±0.04 b	1.97 ±0.03 b
49	2.24 ±0.41 a	2.02 ±0.11 b	2.10 ± 0.34 b	1.95 ± 0.30 b
50	2.21 ±0.09 a	1.92 ± 0.07ab	2.08 ±0.14 ab	1.88 ±0.04 b
51	2.24 ±0.24 a	1.90 ±0.19 b	1.82 ±0.13 b	1.80 ±0.04 b
52	2.34 ±0.13 a	2.00 ±0.05 b	1.94 ± 0.29 b	2.08 ± 0.05 b
53	2.42 ±1.19 a	2.27 ±0.02 b	2.01 ±0.04 b	2.00 ±0.06 b
54	2.24 ± 0.21 a	2.00 ±0.1 b	1.98 ±0.02 b	1.89 ±0.07 b
54-44	2.51 ± 0.04 a	2.06 ± 0.01 b	1.99 ± 0.03b	0.05 ±1.94b

Different letters in a row indicate significant differences between means (P≤0.05) (mean ± S.E).

**Table 8.** Use of betaine and glycine in feed and their effect on the change in live body weight (gm)

Age of hens\ week	live body weight (gm)			
	T1 Control	T2 2.4 gm betaine	T3 2.4 gm glycine	T4 2.4gm betaine+ glycine
44 Initial Weight	1628.00 ±1.97 a	1650.33 ± 86.6 a	1707.70 ±33.40 a	1754.70 ±98.41 a
48	1782.66 ±35.2 a	1755.66 ±31.1 a	1792.66 ±42.85 a	1766.33 ±54.58 a
54 Final weight	1774.66 ±33.0 a	1813.00 ±54.2 a	1808.66 ±61.65 a	1800.66 ±25.91 a

Different letters in a row indicate significant differences between means (P≤0.05) (mean ± S.E).