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EFFECT OF DIETARY BETAINE SUPPLEMENTATION ON PRODUCTIVE, PHYSIOLOGICAL AND IMMUNOLOGICAL PERFORMANCE AND CARCASS CHARACTERISTIC OF GROWING DEVELOPED CHICKS UINDER THE CONDITION OF HEAT STRESS.

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ABSTRACT: The objective of this study was to determine the effect of betaine supplementation on growth performance, carcass characteristics, physiological, and immune response of heat stressed growing chicks, and try to employ some useful properties of betaine for reducing the adverse effect of heat stress conditions. Nine hundred 50% mail and 50% female 8-weeks old of Inshas chicks were divided into three groups with three replicates of 100 chicks each. The birds were reared on floor and assigned to dietary betaine supplementation 0.0, 0.1% and 0.2 % (Treatments A, B and C, respectively). At 13 wks of age each dietary treatment divided into two sub groups of 150 birds with three replicates50 birds each. One sub group of each treatment was exposed to heat stress (39.5 to 41 C°) five hours for five excessive days and another without heat stress. Both feed and water were provided ad-libitum during experimental period (8 to 16 wks). The average daily temperature and relative humidity were 26±3 C° and 66.2±2.5%, respectively. The results indicated that:

1-Each of, body weight, body weight gain and feed conversion significantly ($P \leq 0.01$) improved by dietary betaine supplementation during the first period (8 – 12 wks of age).

Key Words: : Betaine, Carcass, Immunity, Growing, Heat Stress, and Performance

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2- Finial body weight, weight gain, feed conversion values and mortality percentage significantly (P≤ 0.05or P ≤ 0.01) improved by dietary betaine supplementation during the period from 13 - 16 wks of age.

3-Each of rectal temperature, respiratory rate and blood P^H were decreased significantly ,while, T_3 Hormone increased with supplementing betaine in diet as compared with control.

4- Hetrophlic % and H / L ratio were significantly (P ≤ 0.01) decreased, while, lymphocyte % and monocyte % were significantly (P ≤ 0.05) increased by dietry betaine supplementation as compared with control. Hetrophlic and H / L ratio were significantly (P ≤ 0. 01) increased, but lymphocyte and monocyte were significantly (P ≤ 0.01) decreased by exposing to heat stress as compared with unheated groups.

5-Carcass weight, dressing %, thigh%, breast % and giblets% were increased significantly by supplementation betaine to the diets. However, dressing % and breast % were significantly (P ≤ 0.05) decreased by exposure to heat stress as compared with unheated group.

In conclusion, dietary supplemental 0.1% betaine enhanced growth performance, physiological as well as reduced rectal temperature , respiration rate and blood P^H, humoral and cell-mediated immunity and carcass yield for growing developed chickens subjected to heat stress.

INTRODUCTION

Betaine supplementation to livestock diets has increased during the last decade (Feng et al., 2006). Betaine, the trimethyl derivative of the amino acid glycine, is a naturally occurring compound, which is widely distributed in many plants and animal tissues. Due to its chemical structure, betaine has a number of different functions both at the gastrointestinal and metabolic level (Eklund et al., 2005).Due to its osmotic properties; betaine may have the potential to improve the digestibility of specific nutrients (Eklund et al., 2006a and b). Furthermore, betaine is involved in protein and energy metabolism due to its methyl group donor function (Eklundet al., 2005). The addition of betaine to the diet improved weight gain and feed conversion in poultry (Attia et al., 2005). Betaine is an oxidative by-product of choline which serves as an osmo-regulator and is a substrate in the betaine-homocysteine methyltransferase reaction, which links choline and betaine to the foliate-dependent one-carbon metabolism. Betaine is an important source of one-carbon units (Ueland, 2011). Betaine is used by cells to defend against changes in osmolarity (Klasing et al., 2002). Betaine supplement may stimulate protection of intestinal epithelium against osmotic disturbance; improve digestion, absorption and nutrient utilization in broiler chickens (Mahmoudnia and Madani, 2012). Supplementation betaine to diets with adequate methyl group donors improved weight gain and feed efficiency by approximately 3-5 % (Hassan et al ., 2005), although it is considered as a non-essential nutritive substance but it acts as a methyl group donor in transmethylation reactions in organisms (EFSA, 2013). Methyl groups are important for numerous cellular functions such as DNA methylation, phosphatidylcholine synthesis, protein synthesis and fat metabolism (Rima, 2013).

Environmental stress causes oxidative stress and impairs antioxidant status in vivo (Sahin et al., 2006). Under heat stress conditions, supplementation of broiler diets with 0.1% betaine improved weight gain compared with control birds (Farooqi, et al., 2005). On the other hand, Zulkifli et al., (2004) could not show any effects of betaine on weight gain and feed conversion in broilers reared under heat stress conditions. Numerous studies have demonstrated the effect of heat stress on immune parameters in chicken. Kadymov and Aleskerov (1988) concluded that high temperatures inhibit the synthesis of lymphocytes and suppress the phagocytic activity of blood leukocytes. Mashaly et al., (2004) reported a decline in white blood cells (WBC) after exposure to heat stress and decreased heterophil to lymphocyte (H/L ratio) in white leghorn hens .The H/ L ratio has been used as a reliable indicator of stress , and hum oral immunity of birds is depressed . Zulkifli et al., (2004) showed that heat stress caused a reduction in antibody synthesis. The reduction has been ascribed to an increase inflammatory cytokines under stress, which stimulates the hypothalamic production of corticotrophin releasing factor; also heat stress has been known to depress T-helper cytokines, which are important for antibody production (Mashaly et al., 2004). The osmoprotectant action of betaine ameliorates effects of heat stress and of acid-base balance changes (Honarbakhsh et al., 2007) that may compromise physiological and metabolic functions, and consequently, broiler performance and feed efficiency (Honarbakhsh et al., 2007). Supplementation of betaine and ascorbic acid to broiler chickens during the hot-dry season may improve health and production, decrease mortality and increase their productivity (Ayo et al., 2014). The objective of this study was to determine the effect of dietary betaine supplementation to adaptation of the chicks prior exposing to heat stress on growth traits, carcass traits, physiological traits, and immune response of growing chicks under high ambient temperature.

MATERIALS AND METHODS

The present study was carried out at Inshas Research Station, Animal Production Research, Institute, Agriculture Research Center, Ministry of Agriculture, Egypt. Nine hundred chicks 50% male and 50% female at 8-weeks-old of Inshas strain were randomly chosen from a flock reared on floor and divided into three groups of 300 birds each replicate 100 birds . The birds assigned to three dietary betaine supplementation 0.0 (control), 0.1% and 0.2 % to the diet in Table (1). At 13 weeks of age each treatment divided into two sub groups of 150 birds with three replicate 50 birds each. One sub group was exposed to heat stress (39.5 to 41C° daily for five hours for five days) and another without heat stress. During the experimental period feed and water were provided ad- libitum and birds were exposed to 16-hr light daily. The average daily temperature and relative humidity were 26 ±3 C° and 66.2 ± 2.5%, respectively. All birds were individually weighed at the beginning of the experiment, feed consumption, live body weight, body weight gain and mortality rate were recorded every two weeks, feed conversion were calculated. Rectal temperature and respiration rate were measured at 13, 14, 15, and 16 weeks of age after exposure to heat stress. At the end of experimental period (16 weeks of age) six birds (3 males and 3 females) around the average live body weight of each treatment, slaughter characteristics were performed. Carcasses were manually eviscerated to determine some carcass treats, carcass weight, dressing weight percentage (eviscerated carcass without head, and legs) , thighs percentage, breast percentage and total giblets percentage (empty gizzard, liver, heart, and spleen). At the end of the experiment during the time of slaughter taken six samples of blood (10 ml heparinzed blood) for each treatment to determine P^H , T_3 hormone, and immune traits using commercial Kits. Blood PH was determined by using electric PH (JENCO model No 608 USA) immediately after blood samples collection. Heterophil (H) / Lymphocytes (L) ratio (H / L ratio) was calculated according to Gross and Siegel (1983). One hundred different white blood cells were counted and differentiated into lymphocyte and hetrophil and the ratio of H/L was calculated.

Statistical analysis:

The data of productive traits during the first of 4 weeks to experiment (8- 12 wks. of age) were analyzed according to one way model procedure by using SAS (2004). Data was analyzed by adopting the following model:

$Yij = U + Ti + eij$

Yij = An observation, U = The overall mean, Ti = The effect due to treatment levels (i = 0.0, 0.1 and 0.2 % betaine), eij = A random error.

While the data at the end of experiment were subjected to statistical analysis according to general linear model (GLM) of program (SAS,Institute, 2004) with two way ANOVA model using heat stress or control and three level of betaine as main effects. As factorial design (2x3) according the following statically model:

$Y_{ijk}=\mu + P_i + T_j + PT_{ij} + e_{ijk}$

where:

Y_{ijk} = An observation,

μ = Overall mean,

P_i = Effect of heat stress or control (i = 1, 2),

T_j= Effect of the level of betaine (j= 1, 2, 3), PT_{ij}= Effect of interaction between heat stress or control and level of betaine ($_{ij}$=1, ...6) and e_{ijk} = Random error.

Differences among means were tested by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Productive traits:-

1 - Period 1 (8 to 12 weeks of age)

Regarding the effect of dietary betaine supplementation on productive traits during the period from 8 to 12 weeks of age Table (2) showed that live body weight (LBW) and body weight gain (BWG) were significantly ($P \leq 0.01$) increased by dietary betaine supplementation either at 0.1 or 0.2% as compared with control group. Also, Table (2) showed that feed conversion (FC) was significantly ($P \leq 0.01$) improved and mortality rate was decreased by dietary betaine as comparing to control group. These results are agreement with those obtained by (Attia et al., 2005 and Dunshea et al., 2007) Who found that addition of betaine to poultry diet improved significantly body weight. It may be due to have the potential to improve the digestibility of specific nutrients (Eklund et al., 2006a and b). Furthermore, betaine is involved in protein and energy metabolism due to its methyl groups donor function (Eklund et al., 2005). The total betaine need cannot be met by endogenous metabolism, thus, dietary betaine supplementation may be beneficial to maintain or to improve chicken, health and productive performance (Kidd et al., 1997).

2 - Period 2 (13 to 16 weeks of age)

Data presented in Table (3) showed that chicks fed betaine at levels of 0.1 or 0.2 % had significantly ($P < 0.01$) higher final live body weight at 16 weeks of age than the control group. The same trend was obtained for the average body weight gain (BWG), during the period from13 -16 weeks of age. It is worth to mention that feed intake was insignificantly improved by betaine treatments while feed conversion values during the period of 13-16 wks of age was significantly ($P \leq 0.05$) improved by betaine treatments than the control group. However, Mortality percent during the previous period was significantly ($P \leq 0.01$) decreased by betaine treatments than the control group.

The finial BW at 16 weeks of age, BWG and feed conversion values from13 to16 wks of age were significantly ($P \leq 0.05$ or $P \leq 0.01$) decreased by exposing to heat stress comparing the control group(without heat stress). However, mortality percent for the same period was significantly ($P \leq 0.05$) increased by heat stress treatment compared with control group (Table 3).The results agree partially with those observed bySahin et al., (2006) who found depressed growth in rabidly growing broilers are very common symptoms of heat stress. Decreased body weight is attributed to reduction feed intake, which birds divert metabolisabole energy from production to performance in the maintenance of homeothermy (Mckee et al., 1997). Heat stress has been associated with decreases in broiler weight gain, nitrogen retention, protein digestibility and total mineral retention (Sahin and Kucuk, 2003). High temperature has a negative effect on feed intake (Attia et al., 2011). Ayo et al., (2014) reported that heat stress causes decreases in feed intake, conversion of feed to meat, poor weight gain and high mortality, resulting in huge economic losses.

Concerning the effect of interaction, it could be observed that LBW, BWG, FCR and mortality rate were significantly ($P \leq 0.01$) affected by the interaction between betaine supplementation and heat stress treatments at 16 wks of age (Table 3). The highest LBW and BWG and the best FCR from (13 to16 wks) were recorded for chicks fed diet supplemented with 0.2% betaine without exposing to heat stress. On the other hand, the lowest LBW and BWG, and the poorest FCR values were showed by chicks exposed to heat stress and fed diet without betaine additive (Table 3). Mortality percentage from 13 to16 wks of age was increased significantly ($P \leq 0.01$) by exposing to heat stress and fed diet (Table 3).Mortality percentage from 13 to 16 wks of age was significantly ($P \leq 0.01$) decreased by feeding 0.1% betaine without exposing to heat stress, while the highest mortality percent was recorded for those fed the control diet and exposed to heat stress.

These results are close agreement with those obtained by Farooqi et al., (2005) who found that under heat stress conditions, supplementation of broiler diets with 0.1% betaine improved feed conversion as compared with control birds. Similar results were observed with Attia et al., 2005 and Dunshea et al., (2007). Also, Attia et al., (2009) stated that the effect of severe heat stress could partially be overcome by adding 1 kg betaine / ton to chick diets which improved weight gain and feed conversion compared to a negative treatment. It may be due to declines in feed intakes, nutrient utilization, feed efficiency and immunity/ and or reduced antioxidant status in birds, resulting in increased oxidative stress (Khan et al., 2011). In contrast, Zulkifli et al., (2004) could not show any effect of betaine on feed conversion in broilers reared under heat stress conditions.

Physiological traits:- Rectal temperature, respiration rate and blood P^H were significantly ($P \leq 0.01$) decreased while T_3 hormone was increased ($P \leq 0.05$) significantly by dietary betaine supplementation as compared with control group (Table 4). These results were supported by Hassan et al., (2011) who concluded that supplementation betaine in diet significantly reduced rectal temperature and respiration rate in growing rabbits. Under heat stress, rectal temperature, respiration rate and blood P^H were significantly ($P \leq 0.01$) increased as compared with control. However, T_3 hormone was insignificantly decreased by exposing heat stress (Table 4). These findings agreed with those reported by Cronge(2005) who showed a heat-induced increase in rectal and muscle temperatures, leading to a significant body weight loss. Atta (2002) found that T_3 levels were reduced significantly during heat stress. This means Thyroid hormone is an important factor in a response to heat stress .Exogenous thyroid hormone has a shorter survival time during heat stress (Bowen et al., 1984). Also, thyroid size and thyroid activity was reduced by high temperature and increased by low temperature in chicken (Huston et al., 1962).Broiler chickens subjected to heat stress show elevated corticosterone levels and lower levels of thyroid hormones (Mahmoud et al., 2014).

Data in Table (4) illustrated that rectal temperature, respiration rate, P^H blood and T_3 hormone were significantly ($P \leq 0.05$ and $P \leq 0.01$) affected by the interaction between exposure birds to heat stress and dietary betaine supplementation during the 2nd period of experiment (13 – 16 wks of age). The highest rectal temperature, respiration rate and blood P^H were shown by chicks exposed to heat stress and fed diet without betaine additive. On the other hand, the lowest rectal temperature, respiration rate and P^H blood were recorded for chicks fed diet supplemented with 0.2% or 0.1% betaine without exposing to heat stress (Table 4).

At the same Table demonstrated that T_3 hormone levels tended to be significantly ($P \leq 0.05$) increased by the interaction between dietary supplementation betaine and exposure birds to heat stress during the 2nd experiment period 13 – 16 wks of age. These results are in agreement with the work of Zhan et al., (2006) who reported that betaine addition significantly improved alleviated the response of body temperature, rectal temperature decreased 43.2ºC versus 41.9ºC compared to negative control. Brees et al., (1989) observed that blood P^H increased in a curvilinear fashion when chicken was exposed to increasing temperature changes. It may be due to panting results in a loss of CO_2 and an increase in blood p^H, where elevation of blood P^H was concomitant with increase in respiration rate of the present study was interpreted by Balnave and Gorman (1993) who stated that carbon dioxide is an end product of oxidative metabolism in tissues and is converted to carbonic acid through the action of the enzyme carbonic anhydrate. The induction of panting has been shown by Teeter et al., (1999) to result in additional respiratory alkalosis. This respiratory alkalosis causes disruption in blood flow patterns, body water distribution and mineral and ionic balance (Smith and Teeter, 1993). Also, results disagree with those obtained by Gudevi et al., (2011) who found rectal temperature was not influenced by either dietary supplementation of betaine or ambient temperature fluctuation. Accordingly, the highest level of betaine was found in the duodenum, whereas the betaine concentration in the ileum was very low (Kettunen et al., 2001) and (Klasing et al., 2002).

Immunity traits: Data in Table (5) showed that hetrophlic percentage (H) was significantly ($P \leq 0.01$) decreased, but lymphocyte (L) and monocyte (M) percentages were significantly ($P \leq 0.01$, $P \leq 0.05$) increased by betaine supplementation in the diets as compared with control group. H/L was significantly ($P \leq 0.01$) increased. Gudevi et al., (2011) found that feeding 1.5 g/kg supplemental betaine resulted in significant decrease of heterophil percentage ($P<0.05$) and increase of lymphocyte percentage. Awad et al., (2014) reported that lymphocyte percentage (L) count was significantly higher by feeding betaine diets, whereas, heterophils (H) and H/L ratio were significantly decreased compared to the control.

Under heat stress, lymphocyte (L) and monocyte (M) were significantly ($P \leq 0.01$) decreased, but heterophils (H) and H/L ratio were significantly ($P \leq 0.01$) increased by exposure to heat stress as compared with control group. It may be due to humoral immunity of the birds from heat stress is depressed and caused a reduction in antibody synthesis (Zulkifii et al., 2004). This reduction has been ascribed to increases inflammatory cytokines under stress , which stimulates the hypothalamic production of corticotrophin releasing factor, further more heat stress has been known to depress T-helper cytokines, which are important for antibody production ((Mashaly et al ., 2004). Exposure of broilers to acute heat stress caused a decreased monocyte and lymphocyte proportions, whereas, increased the H/L ratio from 0.25 to 0.43 (Amady et al., 2011).

Concerning the effect of interaction, it could be observed that heterophils (H), lymphocyte (L), monocyte (M) and H/L were significantly ($P \leq 0.05$, $P \leq 0.01$) affected by the interaction between betaine supplementation and heat stress treatments at 16 wks of age (Table 5). The highest H % and H/L were exposure to high temperature without betaine supplementation; the lowest L% was exposure to high temperature without betaine supplementation. The results of immune showed that dietary supplementation of betaine to the diet by 0.1 % improvement the immune status during high temperature.

Carcass characteristic: Dietary betaine effects on carcass characteristics are presented in Table (6) it could observed that carcass weight, dressing, thigh, breast and giblets percentages were significantly (P≤ 0.01)improved by betaine supplementation at levels of 0.1 or 0.2% than the control group. These results are closely agreement with those obtained by Noll et al., (2002) and Hassan et al., (2005) who stated that dietary supplementation betaine improved carcass yield and breast muscle yield by approximately 3 -15 % in poultry. Waldroup et al., (2006) reported significant increasing breast meat yield in broiler chickens fed betaine supplementation diets .Dietary supplementation of betaine may be improved of poultry performance and carcass characteristics, even though the effects are variable (Attia et al., 2005 and Dunshea et al., 2007). Breast meat yield was improved 4-10% by addition of betaine (Wang et al., 2004; Waldroup et al., 2006; Zhan et al., 2006). In this context, Waldroup and Fritts (2005) did not find any improvements in breast meat yield of broilers fed diet containing 0.1% betaine. The authors suggested that the response of the bird to betaine supplementation may be age dependent.

Under heat stress dressing and breast percentages were significantly ($P \leq 0.05$) decreased as compared with control (Table 6). The present results confirmed those of Sandercock et al., (2001) who found that acute heat stress caused a reduction in breast muscle in broiler chickens and resulted in accelerated rigor development, reduced water-holding capacity and increased paleness of breast meat.

Table (6) illustrated that dressing and breast percentages were affected significantly ($P \leq 0.01$) by the interaction between heat stress and dietary betaine supplementation during the period of13 – 16 wks of age, whereas, exposure to high ambient temperature, the increasing in breast percentage due to dietary supplementation betaine 0.1 or 0.2 %. The highest dressing and breast percentages were recorded for chicks fed diet supplemented with 0.2 or 0.1% betaine without exposing to heat stress (Table 6). On the other hand, the lowest dressing and breast percentages were recorded for chicks shown by chicks exposed to heat stress and fed diet without betaine additive. It may be due to increase birds tolerance towards higher temperatures with supplementation betaine. These results are agreement with those obtained by Pirompud et al., (2005) who found that supplementing 0.1%

betaine for broiler diets increased breast muscle yield under heat stress.

Economical efficiency:

Data in Table (7) showed that the best economical efficiency (EE) value at the first Period (8 to 12 weeks of age) was recorded for chicks fed diets supplemented with betaine at the level of 0.2% than the other treatment groups.

Also, in this respect results presented in Table (8) revealed that the best (EE) value was shown by chicks fed diets supplemented with betaine at the level of 0.2% than the other treatment groups. While, the lowest (EE) value was shown by chicks exposed to heat stress compared to those of un- heated group (Table 8). Similar results were reported by El-Husseiny et al., (2007) and Patil et al., (2007) who showed that betaine supplementation to poultry diet resulted in a highly economical efficiency value as compared to the control group.

The best value of economical efficiency (EE) was recorded for chicks fed diet supplemented with betaine at level of 0.2% without exposing to heat stress than the other treatment groups, while the purest (EE) was recorded for chicks shown by chicks exposed to heat stress and fed diet without betaine additive (Table 8). Ezzat et al., (2011) found that economical efficiency was improved by betaine supplementation for Matrouh poultry strain from 24-36 weeks of age under Egyptian hot summer condition. Zayed, (2012) reported that economical efficiency was high by feeding diet supplemented with 0.75 and 1.5 g betaine/kg diet for turkey under summer condition.

Conclusion, heat stress causes significant reduction in productive and physiological performance, immune status and carcass characteristics, these implication results in increased disease and economic losses in developed local strain operations. This betaine is one of the most important nutrients to consider when formulating in developed local strain chickens feed for birds exposed to heat stress.

Table (1): Composition and calculated analysis of the basal diets.

Ingredients	%
Yellow corn	65.40
Soybean meal 44%	22.00
Wheat bran	3.00
Di- Cal - Ph.	1.39
Lime stone	7.44
Salt (NaCl)	0.30
Premix *	0.30
Methionine	0.17
Total	100.00
Calculated analysis **	
Crude protein %	16.05
ME K Cal	2726.76
Crude fiber %	3.375
Ca. %	3.804
Total Ph. %	0.619
Lysine %	0.820
Methionine %	0.490

* Each 3kg. ofVit& Min . Mixture contain : Vit A 12000000 IU, Vit D_3 2000000 IU ,Vit E 10.000 mg ,Vit K_3 2000 mg , Vit B_1 1000 mg , Vit , B_2 4000mg , Vit B_6 1500 mg , Vit B_{12} 10 mg , Niacin 50.000mg , Pantothenic acid 10.000 mg , Choline chloride 500.000 mg , Capper 10.000, Iodine 1.000 mg , Iron 30. 00mg, Manganese 55.000 mg, Zinc 55.000 mg and Selenium 100 mg

** According to NRC, (1994).

Table (2): Productive traits of chicks as affected by dietary betaine supplementation during the period from 8 – 12 weeks of age.

Traits maineffects	**Initial bodyweight (g)**	**Body weight at 12 wks. of age**	**Weight gain (g) /day/ bird**	**Feed intake g/ /day/ bird**	**FC (g feed/g gain)/ day**	**Mortality rate %**
Betaine supplementation						
Without bet	728.91±11.22	1010.51±7.91[c]	10.06 ±0.37 [c]	53.29±0.24	5.30 ±0.08 [a]	3.00±0.45
0.1% Bet	731.01±16.64	1093.18±9.09[b]	12.93±0.46[b]	53.66±0.28	4.16 ±0.09 [b]	1.67±0.61
0.2% Bet	728.96± 5.77	1133.66±7.83[a]	14.46±0.30[a]	53.87±0.31	3.73 ±0.04 [c]	1.33±0.42
Sig.	NS	**	**	NS	**	NS

a, b, c,Means within each mean effect within the same column with different litters are significantly different. * * = (P≤ 0.01); * = (P≤ 0.05); and NS = Non- significant.

Table (3): Productive traits of chicks as affected by dietary different levels of betaine, heat stress and their interaction from 13 to 16 weeks of age.

Traitsmain effects		Body weight (g) at12 Wks.	Body weight (g) at 16 Wks.	Weight gain (g) /bird /day.	Average feed intake g/bird/day	FC2 (g) feed/gm. gain)	Mortality rate %
Betaine supplementation							
Without Bet		1010.50 ±7.91 c	1327.13 ±13.33 c	11.31 ±0.45 b	62.03±0.23	5.52 ±0.21 a	7.67 ±0.95 a
0.1% Bet		1093.44 ±9.09 b	1430.67 ±10.97 b	12.06 ±0.45 a	62.78±0.36	5.21 ±0.13 b	4.33 ±0.61 b
0.2% Bet		1133.66 ±7.83 a	1485.57 ±8.92 a	12. 57 ±0.49 a	63.06±0.26	5.03 ±014 b	4.67 ±0.67 b
Sig.		**	**	*	NS	•	**
Heat stress							
Without heat		1080.34±21.85	1433.76±21.63a	12.63±1.14a	62.87±0.26	4.98±0.08b	4.44±0.65 b
Heat stress		1078.05±21.31	1395.01±25.94b	11.32±1.21b	62.37±0.29	5.53±0.14a	6.67±0.75 a
Sig.		NS	*	*	NS	**	*
Interaction between betaine supplementation and heat stress							
0.0% Bet	Control	1012.04±12.27 c	1353.38±19.36 c	12.19±0.70ab	62.13±0.33	5.10±0.11bc	6.00±1.21 b
	Stress	1008.95±10.01c	1300.88±18.46 c	10.42±0.67 b	61.93±0.42	5.94±0.19 a	9.33±0.70 a
0.1% Bet	Control	1096.98±12.46 b	1448.46±16.95ab	12.59±0.51 a	63.29±0.57	5.03±0.18bc	3.33±0.70 b
	Stress	1089.91±13.24b	1412.87±20.10 b	11.54±0.61ab	62.27±0.43	5.40±0.16 b	5.33±0.70 b
0.2% Bet	Control	1132.00±10.98 a	1499.44±19.04a	13.12±0.64 a	63.18±0.19	4.82±0.12c	4.00±1.21 b
	Stress	1135.30±11.19 a	1471.70±20.59 a	12.02±0.66ab	62.93±0.56	5.24±0.22bc	5.33±0.70 b
Sig.		**	**	*	NS	*	**

a, b, c,Means within each mean effect within the same column with different litters are significantly different. * * = (P≤ 0.01); * = (P≤ 0.05); and NS = Non- significant.

Table (4): Some physiological traits of chicks as affected by dietary different betaine levels, heat stress and their interaction at the end of experimental period.

Traitsmain effects		**Rectal temperature**	**Respiration rate**	**Blood PH**	**T3 Level(ng/dl)**
Betaine supplementation					
Without bet		42.23±0.004 [a]	83.33±4.60 [a]	7.34±0.004 [c]	87.17± 7.73 [b]
0.1% Bet		41.60±0.006 [b]	70.17±3.24 [b]	7.12±0.009 [b]	122.45±10.62 [a]
0.2% Bet		41.03±0.006 [c]	63.33±3.11 [c]	7.17±0.003 [b]	131.43±13.26 [a]
Sig.		**	**	**	*
Heat stress					
Without heat stress		41.22±0.006 [b]	61.00±1.52 [b]	7.12±0.006 [b]	124.48±9.10
Heat stress		42.02±0.005 [a]	83.56±2.95 [a]	7.35±0.003 [a]	102.88± 9.84
Sig.		**	**	**	NS
Interaction between betaine supplementation and heat stress					
0.0%	Control	41.62±0.034 [b]	67.83±0.633[cd]	7.22±0.154[ab]	100.33±10.27[ab]
Betaine	Stress	42.85±0.227 [a]	98.83±1.143[a]	7.46±0.122[a]	74.01±9.40[b]
0.1%	Control	41.41±0.036[b]	61.67±0.675[d]	6.91±0.201[c]	135.40±11.67[a]
Betaine	Stress	41.79±0.033[b]	78.67±1.278[b]	7.33±0.197[a]	109.50±17.13[ab]
0.2%	Control	40.63±0.219[c]	53.50± 0.588[e]	7.07±0.170[bc]	137.72±20.67[a]
Betaine	Stress	41.44±0.225[b]	73.17± 0.743[bc]	7.27±0.085[ab]	125.13±18.19[a]
Sig.		*	*	**	*

a, b, c,Means within each mean effect within the same column with different litters are significantly different. * * = (P≤ 0.01); * = (P≤ 0.05); and NS = Non- significant.

Table(5): Immune traits as affected by dietary betaine levels, heat stress and their interaction at the end of experimental period.

traits main effects		Hetrophlic,%	Lymphocyte,%	Eosinphil,%	Monocyte,%	H/L ratios
Betaine supplementation						
Without bet		5.75±0.52[a]	83.17±2.66[c]	1.33±0.14	7.92±0.70[b]	0.72±0.09[a]
0.1% Bet		4.33±0.28[a]	88.08±1.75[b]	1.50±0.16	9.50±1.13[ab]	0.50±0.04[b]
0.2% Bet		3.83±0.41[b]	91.08±2.42[a]	1.68±0.10	8.65±0.97[a]	0.43±0.05[c]
Sig.		**	**	NS	*	**
Stress						
Without heat stress		3.61±0.26[b]	94.39±1.08[a]	1.54±0.12	11.27±0.47[a]	0.39±0.03[b]
Heat stress		5.67±0.35[a]	80.50±1.14[b]	1.45±0.12	6.11±0.43[b]	0.72±0.05[a]
Sig.		**	**	NS	**	**
Interaction between betaine supplementation and heat stress						
0.0% Betaine	control	4.17±0.48[b]	91.50±1.06 [b]	1.38±0.24	9.50±0.43[b]	0.46±0.06[c]
	stress	7.33±0.33[a]	74.83±1.47[d]	1.27±0.20	6.33±0.99[c]	0.98±0.05[a]
0.1% Betaine	control	3.83±0.40[bc]	92.83±1.92[b]	1.56±0.27	12.50±0.62[a]	0.41±0.05[c]
	stress	4.83±0.31[b]	83.33±0.60[c]	1.44±0.26	6.50±0.43[c]	0.58±0.04[b]
0.2% Betaine	control	2.83±0.31[c]	98.83 ±0.95[a]	1.72±0.14	11.80±0.78[a]	0.29±0.03[d]
	stress	4.83±0.48[b]	83.33±0.60[c]	1.63±0.17	5.50±0.76[c]	0.58±0.05[b]
Sig.		**	*	NS	**	**

a, b, c,Means within each mean effect within the same column with different litters are significantly different. * * = (P≤ 0.01); * = (P≤ 0.05); and NS = Non- significant.

Table (6): Carcass traits as affected by dietary betaine levels, heat stress and their interaction at the end of experimental period.

Traitsmain effects		Live body weight (g)	Carcass weight (g)	Dressing %	Thigh%	Breast %	Giblets%
Betaine supplementation							
Without bet		1463.92± 69.11	794.58±38.68[b]	54.21±1.14 [b]	22.73±0.54 [b]	18.48±0.86 [b]	4.62±.10 [b]
0.1% Bet		1583.83± 70.37	938.75±43.82[ab]	61.11±0.85 [a]	25.21±0.84 [a]	22.43±1.14 [a]	5.16±0.15 [a]
0.2% Bet		1617.50± 116.20	1019.58±82.57 [a]	63.04±1.65 [a]	25.07±0.74 [a]	24.42±1.69 [a]	5.17±0.17 [a]
Sig.		NS	*	**	*	**	*
Heat stress							
Without heat stress		1555.94± 65.19	955.83±53.46	61.34±1.26 [b]	24.99±0.71	23.53±1.20 [a]	5.06±0.11
Heat stress		1522.22± 78.85	879.44±49.02	57.77±1.31 [a]	23.69±0.52	20.02±1.01 [b]	4.90±0.15
Sig.		NS	NS	*	NS	*	NS
Interaction between betaine supplementation and heat stress							
0.0% Betaine	control	1511.17±99.48	850.83±62.13	56.30±1.32[bc]	23.85±0.59	19.86±0.62[bc]	4.72±0.06
	Stress	1416.67±101.14	738.33±38.19	52.12±1.63[c]	21.61±0.66	17.10±1.45[c]	4.51±0.20
0.1% Betaine	control	1548.33±92.30	972.50±69.74	62.81±1.11 [a]	25.36±1.68	24.42±1.77[ab]	5.28±0.15
	Stress	1523.33±115.74	905.00±55.97	59.41±1.09[ab]	25.05±0.51	20.44±1.00[bc]	5.04±0.27
0.2% Betaine	control	1608.33±154.89	1044.17±128.94	64.92±2.52 [a]	25.74±1.23	26.32±2.59 [a]	5.18±0.20
	Stress	1626.67±188.17	995.00±114.65	61.17±2.19[ab]	24.40±0.83	22.53±2.09[ab]	5.16±0.30
Sig.		NS	NS	**	NS	**	NS

a, b, c,Means within each mean effect within the same column with different litters are significantly different. * * = (P≤ 0.01); * = (P≤ 0.05); and NS = Non- significant.

Table (7): Input-output analysis and economic efficiency as affected by different levels of betaine from 8 to 12 weeks age.

TraitsMain effects	Total feed intake/ bird (Kg)	Price/Kg. feed (LE)	Total cost/bird (LE)	Weight gain (Kg/bird)	Total revenue/bird (LE)	Net revenue/bird (LE)	Economicefficiency (EE)
Betaine supplementation							
0.0% Betaine	1.492	3.250	4.849	0.28	5.600	0.751	15.488
0.1% Betaine	1.502	3.285	4.934	0.36	7.200	2.266	45.926
0.2% Betaine	1.508	3.320	5.007	0.40	8.000	2.993	59.776

Table(8): Input-output analysis and economic efficiency as affected by different levels of betaine and heat stress and their interactions at the end of experimental period.

TraitsMain effects		Total feed intake/ bird (Kg)	Price/Kg. feed (LE)	Total cost/bird (LE)	Weight gain(Kg/bird)	Total revenue/bird(LE)	Net revenue / bird (LE)	Economic efficiency(EE)
Betainesupplementation								
Control		1.735	3.250	5.639	0.316	6.330	0.691	12.254
0.1% Betaine		1.758	3.285	5.775	0.338	6.760	0.985	17.056
0.2% Betaine		1.766	3.320	5.863	0.352	7.040	1.177	20.075
heat stress								
Without heat stress		1.760	3.285	5.782	0.354	7.080	1.298	22.449
Heat stress		1.747	3.285	5.739	0.317	6.340	0.601	10.472
Interaction between betainesupplementation and heat stress								
0.0% Bet	control	1.740	3.250	5.655	0.341	6.820	1.165	20.601
	Stress	1.734	3.250	5.636	0.292	5.840	0.204	3.620
0.1% Bet	control	1.772	3.285	5.821	0.353	7.060	1.239	21.285
	Stress	1.744	3.285	5.729	0.323	6.460	0.731	12.760
0.2% Bet	control	1.769	3.320	5.873	0.367	7.340	1.467	24.980
	Stress	1.762	3.320	5.850	0.337	6.740	0.890	15.214

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الملخص العربى

تأثير إضافة البيتايين للعليقة على الأداء الإنتاجي والفسيولوجي والمناعي ومكونا ت الذبيحة للدجاج المستنبط النامي تحت ظروف الإجهاد الحراري.

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أجريت هذه التجربة لدراسة تأثير إضافة مستويات مختلفة من البيتايين على أداء الصفات الإنتاجية والفسيولوجية والمناعية ومكونات الذبيحة في الدجاج المستنبط النامي . تم تقسيم عدد ٩٠٠ كتكوت عمر ٨ أسابيع من سلالة أنشاص إلى ٣ معاملات بكل معاملة ٣٠٠ كتكوت (٣ مكررات كل مكررة ١٠٠ كتكوت) وكانت التربية أرضية . تم إضافة البيتايين كالاتي :- المعاملة الأولى بدون إضافة (كنترول) وتم إضافته إلى المعاملة الثانية بمستوى ٠,١ % . وإضافته إلي المعاملة الثالثة بمستوى ٠,٢ % . وعند ١٢ أسبوعا من العمر تم تقسيم كل معاملة إلى مجموعتين كل مجموعة ١٥٠ طائر (كل مكررة ٥٠ طائر) أحدهما بدون تعرض للحرارة العالية والأخرى تم تعريضها إلى درجة حرارة عالية (٣٩,٥ إلى ٤١,٠ م لمدة ٥ ساعات لخمسة أيام متتالية) في أواخر فصل الشتاء. وتم تغذية الطيور للشبع والماء بصورة حرة من ٨ إلى ١٦ أسبوعا من العمر . وكان متوسط درجة الحرارة ٢٦ ±٣ درجه مئويه والرطوبة ٦٦± ٢,٥ % على التوالي خلال فترة إجراء التجربة خلال شهور نهاية فبرايرو مارس وابريل.

وكانت النتائـــج كالتالي:

١- تحسن كلا من وزن الجسم ومعدل التحويل معنويا (٠,٠١ %) بإضافة مستويات البيتايين أثناء الفترة الأولى من التجربة (٨ – ١٢ أسبوعا من العمر) .

٢- تحسن كلا من وزن الجسم في نهاية التجربة ومعدل النمو ومعدل التحويل ونسبة النفوق معنويا (٠,٠١ %) بإضافة مستويات البيتايين أثناء الفترة الثانية من التجربة (١٣ –١٦ أسبوعا من العمر) بينما الغذاء المأكول لم يتأثر بالمقارنة بالكنترول .

٣- انخفض كلا من درجة حرارة المستقيم ومعدل التنفس و P^H الدم معنويا (٠,٠١) بإضافة مستويات البيتايين إلى العليقة بينما ازداد T_3 عند المقارنة بالكنترول .

٤- إضافة البيتايين إلى العليقة أدى إلى تحسين المناعة على مستوى (٠,٠١) بينما التعرض للإجهاد الحراري أدى إلى انخفاض المناعة بارتفاع النسبة بين H/L و انخفاض خلايا Monocytes وخلايا Lymphocytes معنويا عند المقارنة بالكنترول. وبإضافة البيتايين إلى العليقة بمستوى ٠,١% أثناء التعرض للإجهاد الحراري أدى إلى التخفيف من التأثيرات الضارة للإجهاد الحراري على أداء النمو والمناعة ودرجة حرارة الجسم ومعدل التنفس و قلوية الدم.

٥- تحسن كلا من وزن الذبيحة ووزن الصدر معنويا (٠,٠١) بإضافة مستويات البيتايين إلى العليقة بينما كلا من وزن الفخذين والأجزاء الداخلية المأكولة لم يتأثر معنويا عند المقارنة بمجموعة الكنترول .

التوصيـــــة : إضافة البيتايين بمعدل ٠,١% إلى العليقة أدى إلى تحسين ألأداءالانتاجى والفسيولوجي بخفض درجة حرارة الجسم ومعدل التنفس و درجة قلوية الدم ويزيد من المناعة ووزن الذبيحة أثناء نمو الدجاج المستنبط عند التعرض للإجهاد الحراري .