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# EFFECT OF DIETARY ENERGY LEVEL ON THE BROILER RESPONSE TO CHOLINE SUPPLEMENTS DURING SUMMER SEASON

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**SUMMARY:** This study was carried out at the Poultry Research Station, El-Azab, Fayoum, Egypt during the period from June to August 2011. A total numbers of 168 one-day old unsexed Ross broiler chickens were initially fed a control diet for four days. This experiment was conducted to study the effect of using two levels (0.00 and 0.10%) of choline and each with four levels of ME (recommended (R), R-100, R-200 and R-300 Kcal/Kg diet) in 2 x 4 factorial arrangement giving eight dietary treatments on performance of broiler chicks.

***Results obtained could be summarized in the following:***

**Productive performance:** The main effects of cho., level of ME and interaction due to level of cho.% x dietary ME Kcal/Kg diet had insignificantly affected LBW and LBWG during the period from 5 to 42 days. The main effects of cho. had significantly affected FI and FC during the period from 5 to 42 days, cho. supplementation (0.1%) decrease FI and improve FC during the previous period as compared with those fed cho. un-supplement diet. Dietary ME effect and interaction due to level of cho.% x dietary ME Kcal/Kg diet were significant for FI during the period from 5 to 42 days. It is clear that, chicks fed R-100 Kcal/Kg diet had significantly higher value of FI (chicks fed control diet had lower value) during the same period. Interaction due to level of cho.% x dietary ME Kcal/Kg diet had insignificantly affected CPC, CCR, GR and PI during the period from 5 to 42 days.

**Slaughter parameters% and blood constituents:** neither cho.% nor interaction between cho.% x dietary ME Kcal/Kg diet had any significant effect on slaughter parameters% and blood constituents, also, no significant differences were detected in blood constituents due to dietary ME Kcal/Kg diet.

**Economical efficiency (EEf):** EEf values during the period from 5 to 42 days of age improved in chicks fed all experimental diets as compared with those fed the control diet (chicks fed cho. un-supplement diet with R-300 Kcal/Kg diet had the best economical and relative efficiency values).

**It would be concluded that,** dietary ME can be reduced from the recommended level up to 300 Kcal/Kg diet and supplement these diets with choline specifically under summer conditions without affecting Ross broiler performance.

**Key words:** Energy, choline, triticale, summer season and broiler performance.

## INTRODUCTION

Poultry industry is increasing dramatically throughout the developing countries. The key for successful process in poultry projects is through maximizing the profit, on the other hand, minimizing the feed cost could be achieved through the use of untraditional feed grains (particularly from local producers) or improving utilization of common feeds by using some additives and efforts to reduce dietary energy level have been the subject of numerous investigators. That can serve as a partial solution to widespread protein malnutrition in most developing countries in the tropics. **Slagter and Waldroup (1990) and Hunton (1995)** reported that a change in the energy content of the diet will normally result in an inverse change in the total amount of feed consumed and will therefore influence the intake of essential nutrients. Therefore, deficiency of nutrients may occur in poultry by increasing the energy content in diet especially during summer season. Feed additives are important materials that can improve the efficiency of feed utilization and animal performance. Vitamin supplementation of commercial compound feed is mostly oriented towards recommendations for supplemental choline. Choline is a positively charged quaternary amine, water soluble nutrient that has been grouped within the B-complex vitamins **(Zeisel *et al.,* 1991).** However, other author has theorized that optimal nutrition requires dietary choline but this nutrient is not a vitamin. The functions of choline in animals have no resemblance to the B vitamins, vitamin C, or the fat-soluble vitamins, its metabolism are more akin to the amino acids than any other class of nutrients **(Garrow, 2007)**. Choline is found in food as free choline, phosphocholine, glycerophosphocholine, phosphatidylcholine, and sphingomyelin; all of which can be converted to choline or revert to their original form **(Zeisel and daCosta, 2009)**. Choline cannot be stored in the body so choline in excess of essential needs is oxidized to betaine (betaine cannot be converted back to choline). Choline contributes to vital biological functions of body, **Dilger *et al.* (2007)** reported that dietary choline is essential for the production of acetylcholine (i.e.neurotransmission), phosphatidylcholine from phosphatidylethanolamine (i.e. cell membrane integrity), choline plasmalogen, lysophosphatidylcholine, sphingomyelin, creatine from guanido acetic acid all of which are essential components for maintain the integrity of cell membranes and of lecithine, which is a component of egg yolk **(Zeisel *et al.,* 1991).** On the other hand, dietary choline deficiency is associated with liver and muscle dysfunction **(Zeisel *et al.,* 1991 and Albright *et al.,* 2005)**, fatty liver and perosis in poultry, inflammation and DNA hypomethylation **(Pogribny *et al.,* 2006)**. The oxidation of choline is an energy yielding process **(Garrow, 2007).** Choline, methionine, betaine and folate are methyl group donors that act as S-adenosine methionine metabolism**,** methylation of DNA, RNA, protein and histone **(Kidd *et al.,* 1997 and Dunlevy *et al.,* 2006).** According to **Finkelstein (2000),** choline interacts with methionine and folate to achieve this one-carbon methylation and reduce the amount of homocysteine (toxic in high concentrations). Modifying the intake of choline nutrients could alter lipid metabolism and methylation especially in the case of choline deficiency (**Niculescu *et al.*, 2006).**

Choline in typical feedstuffs is not completely available for absorption, however choline chloride is regarded as an effective source of choline in the diets of poultry considered 100% bio-available, choline chloride metabolized into choline in the body **(Wu and Davis, 2005).** Requirements for choline are in the range of 300–2000 mg/kg feed for poultry **(McDowell, 2000)**. The young chick has a high requirement for dietary choline (that cannot be replaced by high levels of dietary methionine or other methyl donors) which decreases with increasing age **(NRC, 1994).** In this respect, **Lowry *et al.* (1987)** determined that the minimal concentration of dietary choline for chicks to achieve maximal growth rate was 625 mg/kg and 722 mg/kg diet is optimal for normal growth **(Dilger *et al.*, 2007).**

In Egypt one of the major problems challenging our poultry industry is the high ambient temperature, which persists for almost 5 months of the year from May to September. Ambient temperature is the most environmental factor, which affects all physiological processes and productive performance of poultry. Poultry experiences heat stress when there is high ambient temperature, accompanied by high relative humidity zones. In this regard, **Cerci *et al.* (2003)** and **Sahin *et al.* (2006)** determined that, the suitable temperature for poultry is between 16 and 25°C and relative humidity of 60-70% is ideal for broiler (**Hoffman and Gwin, 1954).** Likewise, **Bollengier *et al.* (1998)** found that heat stress begins when the ambient temperature becomes higher than 27°C and is readily apparent above 30°C**.** Chickens do not have sweat glands, a rapid metabolism, so they are more sensitive to high ambient temperatures. Thus it has become necessary to avoid heat stress in order to prevent unnecessary suffering such as metabolic disturbances, cell injury and changes in enzyme activity (**Sahin and Kucuk, 2003)**, depressed immune function also causes mortality **(Younis, 2007)** and causes the loss of revenue that ranges into millions of dollars each year **(Mahmoud *et al.,* 2003).** The recognition of heat stress as a problem for efficient broiler production in hot weather has led to many research efforts such as genetic, nutritional and housing environment to alleviate the problem (**Linn *et al.*, 2006).** A considerable amount of research has been conducted upon nutritional parameters such as decreasing dietary metabolizable energy (ME) and high protein rations, etc (**Baghel and Pradhan, 1990** and **Hoffmann *et al.*, 1991)**. The energy requirement of birds decreases as the ambient temperature increases above 21°C **(Daghir, 1983).** Any excess energy consumption is deposited primarily as fat in the body which indicating the wastage of dietary energy and birds obesity is normally associated with lower production, feed efficiency **(Hocking *et al*., 2002),** reproductive failure, death due to heart failure and impaired thermoregulation **(Garlich, 1979)**. So, it is necessary to provide adequate energy intake during the summer month to control body heat and to get good performance.

In addition to this, high environmental temperatures may cause water imbalance and osmotic change in cells from dehydration. It is known that changes in cell water volume can affect cell activity **(Sahin *et al.,* 2009).** Choline serves as a methyl donor for conversion of homocysteine to methionine following its oxidation to betaine. Betaine is a tertiary amine formed by the oxidation of choline **(Wang *et al.,* 2004).** Several scientific publications showed the betaine is also required by renal glomerular cells, which use betaine and glycerophosphocholine as organic osmolytes to overcome the negative effects of dehydration of high temperature or diseases **(Burg, 1995 and Garcia *et al*., 2000).** Furthermore, as observed by **Cromwell *et al.* (1999); Wray *et al.* (2004)** and **Dunshea *et al.* (2009),** the effect of betaine supplementation was more pronounced when dietary energy was limiting and/or stressful conditions. Moreover, under specific conditions of energy limitation in combination with a mild environmental stress betaine supplementation might enhance the energetic value of diets **(Schrama *et al.,* 2003)**.

The traditional feed grains corn and soybeans, are not produced (in Egypt) in quantities that make them available to poultry. So, triticale is a relatively new feed grains that is not used to any great degree in poultry feed (**Hermes and Johnson, 2004 and Emam, 2010)**. Triticale (an alternative cereal grains that is a hybrid of wheat and rye) was developed to combine the high crude protein (CP) and digestible energy of wheat with the high yields and protein quality of rye. Triticale grains are a good source of minerals, especially the phosphorus content which ranges from 300 to 358 mg/100g **(NRC, 1994** and **Emam, 2010).** In several studies with broilers show no differences in productivity, even when diets consist of 100% triticale (**Maurice *et al.,* 1989, Emam, 2010 and Ragab, 2013**). Further, **Chapman *et al.* (2005)** indicated that the daily live body weight gain (LBWG) for the diets using triticale was 5% higher than for the corn-based diet.

Little previously conducted research has tested on the use of choline at lower levels of ME during the summer season conditions, however, thus may give us the opportunity to take appropriate preventive to avoid the adverse effects of hot summer months. Considering the above statements, the purpose of the present study was to determine the effects of choline supplementation in broiler diets varying in their energy content during the summer period on growth performance, slaughter parameters, some blood constituents, mortality rate, and economical efficiency.

## MATERIALS AND METHODS

This study was carried out at the Poultry Research Station, El-Azab, Fayoum, Egypt during the period from June to August 2011. Chemical analyses were performed in the laboratories of the Poultry Research Station, Poultry Production Department, Faculty of Agriculture, Fayoum University. This experiment was conducted to study the effect of using two levels (0.00 and 0.10%) of choline (1.67% a dry choline chloride product (60% choline) were added to the diets) and each with four levels of ME (recommended (R), R-100, R-200 and R-300 Kcal /Kg diet) in 2 x 4 factorial arrangement (giving eight dietary treatments) on growth, feed utilization and economical efficiency of broiler chicks. Accordingly, a total numbers of 168 one-day old unsexed Ross broiler chickens were initially fed a control diet for four days.

*The experimental treatments were as follows:*

**1**- Chicks were fed the control diet ($T_1$). **2**- $T_1$ -100 Kcal ME/Kg diet ($T_2$).
**3**- $T_1$ -200 Kcal ME/Kg diet ($T_3$). **4**- $T_1$ -300 Kcal ME/Kg diet ($T_4$).
**5**- $T_1$ +0.1% choline ($T_5$). **6**-$T_1$-100 Kcal ME/Kg diet+0.1% choline ($T_6$).
**7**- $T_1$ -200 Kcal ME/Kg diet + 0.1% choline ($T_7$).
**8**- $T_1$ -300 Kcal ME/Kg diet + 0.1% choline ($T_8$).

At five days of age, birds were divided into eight treatments (21 birds each), each treatment contained three replicates of seven birds each. Chicks were raised in electrically heated batteries with raised wire mesh floors and had a free access of feed and fresh water from nipple drinkers (2 nipples/cage) up to 42 days of age. Batteries were placed into a room provided with a continuous light (23 h/d up to 42 days) and fans for ventilation. The experimental birds were reared under similar environmental conditions (open system), and were fed starter diet from five to 11 day, grower diet from 12 to 23 day, and finisher diet from 24 day to the end of the experiment at 42 day of age (triticale-soy bean meal basal diet). The composition and calculated analysis of the experimental diets are presented in Table (1). The experimental diets were supplemented with minerals and vitamins mixture, DL-methionine and L-Lysine HCl to cover the recommended requirements according to the strain catalog recommendations and were formulated to be iso-nitrogenous.

The tested raw material was analyzed for moisture, CP, ether extract (EE), crude fiber (CF), ash, nitrogen free extract (NFE)% and ME Kcal/Kg, by the methods outlined by Association of Official Analytical Chemists, **A.O.A.C. (1990)**. The determined chemical analysis (**Emam, 2013)** of triticale grains (the triticale grains used in the present study were obtained from the Agricultural Research Center, Ministry of Agriculture, Dokki, Egypt, then grown locally in Fayoum Governorate (yield, 2010)) showed that triticale grains contained, 10.19, 12.51, 0.99, 4.06, 1.85, 70.40% and 2999.95 for moisture, CP, EE, CF, ash, NFE% and ME Kcal/Kg, respectively (the ME value was calculated according to **Janssen (1989)** by applying the equation:

Triticale MEn (Kcal/kg)=(34.49×CP)+(62.16×EE)+(35.61×NFE). And soy bean meal contained, 10.10, 42.01, 1.89, 4.47, 2.53, 39.00% and 2230.0 for moisture, CP, EE, CF, ash, NFE% and ME Kcal/Kg (the ME value was calculated according to **NRC, 1994**), respectively.

Birds were individually weighed to the nearest gram at 5,11,23 and 42 days of age intervals during the experimental period. At the same time, feed consumption was recorded and LBWG, feed conversion (FC), crude protein conversion (CPC), caloric conversion ratio (CCR) and growth rate (GR) (g feed/g gain) were calculated. Performance index (PI) was calculated according to the equation described by **North (1981)** as follows: PI = (live body weight (LBW),Kg/FC) x100. The vaccination program adopted by recommended requirements according to standard commercial guidelines. Accumulative mortality rate was obtained by adding the number of dead birds during the experiment divided by the total number of chicks at the beginning of the experimental period.

**Table 1: Composition and analyses of the experimental diets.**

| Items | Starter (5-11 days) | | | | Grower (12-23 days) | | | | Finisher (24-42 days) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Level of ME, kcal./Kg | | | | | | | | | | | |
| | R[1] | R-100 | R-200 | R-300 | R | R-100 | R-200 | R-300 | R | R-100 | R-200 | R-300 |
| **Triticale, ground** | 59.09 | 59.00 | 59.00 | 59.00 | 62.57 | 61.00 | 61.50 | 61.00 | 65.00 | 65.00 | 65.00 | 65.00 |
| **Soybean meal** | 23.00 | 24.00 | 25.00 | 26.02 | 17.32 | 20.44 | 22.51 | 26.00 | 16.00 | 19.00 | 21.31 | 22.00 |
| **Corn glutein meal** | 9.41 | 8.49 | 7.58 | 6.65 | 10.31 | 8.28 | 6.80 | 4.60 | 7.56 | 5.59 | 4.00 | 3.23 |
| **Wheat bran** | 0.00 | 1.14 | 2.21 | 3.29 | 0.00 | 1.28 | 1.41 | 1.58 | 0.88 | 0.96 | 1.36 | 2.60 |
| **Calcium carbonate** | 1.55 | 1.55 | 1.55 | 1.55 | 1.40 | 1.40 | 1.40 | 1.42 | 1.34 | 1.35 | 1.36 | 1.37 |
| **Sodium chloride** | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| **Vit. and trace Min. premix[2]** | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| **Monocalcium phosphate** | 1.73 | 1.73 | 1.72 | 1.70 | 1.56 | 1.51 | 1.50 | 1.48 | 1.43 | 1.40 | 1.38 | 1.36 |
| **Vegetable oil [3]** | 3.86 | 2.75 | 1.62 | 0.49 | 5.63 | 4.94 | 3.76 | 2.86 | 6.80 | 5.76 | 4.70 | 3.56 |
| **DL – Methionine** | 0.26 | 0.26 | 0.27 | 0.27 | 0.17 | 0.18 | 0.19 | 0.20 | 0.10 | 0.11 | 0.11 | 0.12 |
| **L-Lysine Hcl** | 0.50 | 0.48 | 0.45 | 0.43 | 0.44 | 0.37 | 0.33 | 0.26 | 0.29 | 0.23 | 0.18 | 0.16 |
| **Total** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| **Calculated analysis[4]:** | | | | | | | | | | | | |
| **Crude protein** | 23.50 | 23.50 | 23.50 | 23.50 | 22.00 | 22.00 | 22.00 | 22.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| **Ether extract** | 5.12 | 4.04 | 2.94 | 1.84 | 6.84 | 6.18 | 5.01 | 4.13 | 7.97 | 6.94 | 5.90 | 4.79 |
| **Linoleic acid** | 2.69 | 2.07 | 1.43 | 0.80 | 3.69 | 3.30 | 2.65 | 2.15 | 4.36 | 3.79 | 3.20 | 2.56 |
| **Crude fiber** | 3.70 | 3.85 | 4.00 | 4.16 | 3.60 | 3.79 | 3.90 | 4.03 | 3.71 | 3.83 | 3.96 | 4.11 |
| **Calcium** | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.90 | 0.90 | 0.90 | 0.85 | 0.85 | 0.85 | 0.85 |
| **Available phosphorus** | 0.50 | 0.50 | 0.50 | 0.50 | 0.45 | 0.45 | 0.45 | 0.45 | 0.42 | 0.42 | 0.42 | 0.42 |
| **Methionine** | 0.69 | 0.69 | 0.69 | 0.69 | 0.59 | 0.59 | 0.59 | 0.59 | 0.48 | 0.48 | 0.47 | 0.48 |
| **Methionine+Cystine** | 1.09 | 1.09 | 1.09 | 1.09 | 0.97 | 0.97 | 0.97 | 0.97 | 0.83 | 0.83 | 0.83 | 0.83 |
| **Lysine** | 1.44 | 1.44 | 1.44 | 1.44 | 1.25 | 1.25 | 1.25 | 1.25 | 1.05 | 1.05 | 1.05 | 1.05 |
| **ME, kcal./Kg** | 3010.6 | 2910.1 | 2810.1 | 2709.8 | 3175.6 | 3075.0 | 2975.5 | 2875.5 | 3225.6 | 3124.8 | 3025.2 | 2925.1 |
| **C/P ratio** | 128.10 | 123.84 | 119.57 | 115.30 | 144.35 | 139.79 | 135.25 | 130.68 | 161.27 | 156.23 | 151.25 | 146.29 |
| **Cost (£.E./ton) [5]** | 2449.8 | 2361.1 | 2273.2 | 2182.5 | 2467.2 | 2381.0 | 2282.8 | 2186.1 | 2378.7 | 2279.4 | 2180.9 | 2095.9 |
| **Relative cost [6]** | 100.00 | 96.38 | 92.79 | 89.09 | 100.00 | 96.51 | 92.52 | 88.61 | 100.00 | 95.83 | 91.69 | 88.11 |

[1] Recommended [2]Each 3.0 Kg of the Vit. and trace Min. premix manufactured by Agri-Vet Company, Egypt and contains : Vit. A, 12000000 IU; Vit. $D_3$ 2000000 IU; Vit. E, 10 g; Vit. $K_3$, 2.0 g; Vit. B1, 1.0 g; Vit. B2, 5 g; Vit. B6, 1.5 g; Vit. B12,10 mg; choline chloride, 250 g; biotin, 50 mg; folic acid, 1 g; nicotinic acid , 30 g; Ca pantothenate, 10 g; Zn, 50 g; Cu,10 g; Fe, 30 g; Co, 100 mg; Se, 100 mg; I, 1 g; Mn, 60 g and anti-oxidant, 10 g, and complete to 3.0 Kg by calcium carbonate. [3] Mixture from 75% soybean oil and 25% sunflower oil. [4] According to **NRC, 1994** (except triticale and soybean meal were analysis before start the experiment). [5] According to the local market price at the experimental time. [6] Assuming the price of the control group equal 100.

Slaughter tests were performed using three chicks around the average LBW of each treatment at 42 days of age (the end of the experimental period). The birds were on feed withdrawal overnight (approximately 12h), then individually weighed to the nearest gram, and slaughtered by severing the jugular vein (Islamic method). After four minutes bleeding time, each bird was dipped in a water bath for two minutes, and feathers were removed. After the removal of head, carcasses were manually eviscerated to determine some carcass traits, dressing% (eviscerated carcass without head, neck and thighs) and total giblets% (gizzard empty, liver, heart and spleen). The eviscerated weight included the front part with wing and rear part.

The abdominal fat was removed by hand from the parts around the viscera and gizzard, and was weighed to the nearest gram. The bone of front and rear were separated and weighed to calculate meat percentage. The meat from each part was weighed and blended using a kitchen blender. Also, individual blood samples were taken from three birds. The biochemical characteristics of blood were determined colorimetrically, using commercial kits.

The economic efficiency was calculated as the price of body weight gain–total costs of raising a broiler as relative to total raising costs which was estimated based upon local current prices at the experimental time. Statistical analysis of results was performed using the General Linear Models (GLM) procedure of the SPSS software (version 16, SPSS Inc., Chicago, IL), according to the follow general model:

$$\mathbf{Y_{ijk}= \mu+C_i+E_j+CE_{ij}+e_{ijk}}$$

Where: $\mathbf{Y_{ijk}}$**:** observed value $\mu$**:** overall mean

$\mathbf{C_j}$: choline supplementation effect (**j**: 0.0 and 0.1%)

$\mathbf{E_i}$**:** level of ME effect (**i**: -100, -200 and -300 Kcal ME/Kg diet)

$\mathbf{CE_{ij}}$: interaction of level of energy effect by choline supplementation effect

$\mathbf{e_{ijk}}$: random error

Treatment means indicating significant differences (P≤0.01 and P≤0.05) were tested using Duncan's multiple range test **(Duncan, 1955)**.

## RESULTS AND DISCUSSION:

**Productive performance:** Effect of choline supplementation (cho.) to triticale diets varying in their ME content on LBW and LBWG are shown in Table 2. The main effects of cho. had insignificantly (P>0.05) affected LBW and LBWG during all periods studied except, LBWG during the period from 5 to 11 days which was significantly (P≤0.05) affected, this may be partially attributed to the young chick has a high requirement for dietary choline which decreases with increasing age because they do not have fully functional S-methyl transferase enzymes at an early age (Table 2). Numerically, as shown in Table 2, cho. supplementation (0.1%) increase LBW and LBWG during all experimental periods studied compared with those fed cho. un-supplement diet (0.0%), however, these did not reach a level of statistical significance.

**Table 2: Effect of dietary energy level on live body weight (LBW,g) and live body weight gain (LBWG,g) of broiler response to choline supplements.**

| Items | | LBW,g (age, days) | | | | LBWG,g (age period, days) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 11 | 23 | 42 | 5-11 | 12-23 | 24-42 | 5-42 |
| **Choline (Cho.)%:** | | | | | | | | | |
| **0.00** | | 111.24 | 201.11 | 717.42 | 1664.3 | 91.08[b] | 515.64 | 920.50 | 1550.2 |
| **0.10** | | 111.19 | 208.73 | 732.50 | 1672.1 | 99.62[a] | 521.75 | 947.67 | 1571.5 |
| **SEM[1]** | | 1.74 | 3.60 | 13.49 | 33.46 | 2.55 | 12.90 | 26.07 | 32.73 |
| **P-value** | | 0.985 | 0.139 | 0.443 | 0.875 | 0.020 | 0.742 | 0.488 | 0.665 |
| **ME, kcal./Kg (ME):** | | | | | | | | | |
| **Recommended(R)** | | 111.32 | 206.16 | 671.51[c] | 1589.3 | 97.12 | 463.70[c] | 931.80 | 1498.9 |
| **R-100** | | 110.99 | 207.00 | 778.62[a] | 1760.6 | 96.01 | 569.59[a] | 963.99 | 1647.1 |
| **R-200** | | 111.78 | 203.81 | 746.55[ab] | 1678.5 | 94.45 | 543.46[ab] | 927.05 | 1566.6 |
| **R-300** | | 110.76 | 202.71 | 703.17[bc] | 1644.5 | 93.82 | 498.03[bc] | 913.51 | 1530.8 |
| **SEM** | | 2.46 | 5.04 | 19.08 | 44.07 | 3.51 | 17.89 | 34.34 | 43.11 |
| **P-value** | | 0.992 | 0.926 | 0.001 | 0.141 | 0.914 | <0.001 | 0.834 | 0.218 |
| **Cho.% × ME (treatments):** | | | | | | | | | |
| **0.00** | **R** | 111.10 | 202.58 | 669.32 | 1596.0 | 91.48 | 462.44 | 892.22 | 1483.5 |
| | **R-100** | 111.77 | 200.83 | 784.69 | 1762.0 | 89.06 | 583.86 | 947.11 | 1644.0 |
| | **R-200** | 111.05 | 200.83 | 717.68 | 1639.3 | 94.63 | 519.67 | 911.42 | 1528.9 |
| | **R-300** | 111.03 | 200.18 | 698.01 | 1659.8 | 89.15 | 496.59 | 931.26 | 1544.4 |
| **0.10** | **R** | 111.55 | 209.73 | 673.69 | 1582.5 | 102.7 | 464.97 | 971.38 | 1514.3 |
| | **R-100** | 110.21 | 213.16 | 772.56 | 1759.2 | 103.0 | 555.32 | 980.87 | 1650.1 |
| | **R-200** | 112.50 | 206.78 | 775.41 | 1717.8 | 94.28 | 567.24 | 942.67 | 1604.3 |
| | **R-300** | 110.50 | 205.23 | 708.33 | 1629.1 | 98.50 | 499.47 | 895.77 | 1517.2 |
| **SEM** | | 3.47 | 7.13 | 26.48 | 62.33 | 4.96 | 24.83 | 48.56 | 60.79 |
| **P-value** | | 0.977 | 0.958 | 0.619 | 0.859 | 0.554 | 0.545 | 0.741 | 0.883 |

**[a–c] Means in a column with different superscripts differ significantly ($P \leq 0.05$). [1] Pooled SEM**

Dietary ME effect was significant for LBW at 23 days and LBWG during the period from 12 to 23 days of age (Table 2). It is clear that, chicks fed R-100 Kcal/Kg diet had significantly higher values of LBW at 23 days and LBWG during the period from 12 to 23 days of age (differences between R-100 and R-200 Kcal/Kg diet were not significant), while, chicks fed control diet had significantly lower LBW and LBWG values during the previous period. However, level of ME had insignificant effect on LBW at 5, 11 and 42 days and LBWG during the periods from 5 to 11, 24 to 42 and 5 to 42 days. Similar to the present findings **Leeson *et al.* (1996a)** found that LBW and LBWG were unaffected by level of energy in the diet over the range 2700 to 3300 Kcal ME/kg. Also, **Giachetto *et al.* (2003)** observed that no significant difference in final LBW was found between the birds fed with different energy levels (2900 or 3200 kcal ME/kg). While, **Ragab (2013)** concluded that level of ME in broiler diet had a significant effect on LBW at 23 and 42 days and LBWG during the periods from 12 to 23 and 5 to 42 days of age (chicks fed recommended level of ME - 100 Kcal/Kg diet had higher LBW and LBWG during these periods).

Interaction due to level of cho.% x dietary ME Kcal/Kg diet had insignificantly (P>0.05) affected LBW and LBWG during all periods studied (Table 2). Numerically, all dietary treatments improved LBW at 23 and 42 days (except, chicks fed cho. supplement (0.1%) diets with recommended level of ME) and LBWG during the periods from 12 to 23, 24 to 42 and 5 to 42 days as compared with those fed control diet (but differences were not significant). It can be concluded that dietary ME can be reduced from the recommended level up to 300 Kcal/Kg diet and supplement these diets with cho. without affecting LBW and LBWG.

Effect of cho. supplementation to triticale diets varying in their ME content on feed intake (FI) and FC at different ages are shown in Table 3. The main effects of cho. had significantly affected FI during the periods from 12 to 23, 24 to 42 and 5 to 42 days and FC during the periods from 5 to 11, 24 to 42 and 5 to 42 days. As shown in Table 3, cho. supplementation (0.1%) decrease FI and improve FC during the periods from 24 to 42 and 5 to 42 days of age as compared with those fed cho. un-supplement diet. The aforementioned results are in agreement with those of **Waldroup *et al.* (2006)** who reported that, numerical improvements in LBW and significantly improved FC were frequently observed when addition of 1000 mg of cho./kg over the birds fed the unsupplemented diets at 35, 42, 49, and 56 d of age. Similarly, **Dilger *et al.* (2007)** reported that supplementation of the cho. free basal diet with graded levels of cho. resulted in linear increases in LBWG, FI and improved FC. Also, **Jadhav *et al.* (2008)** found that a significant increase in LBW and significant improvement in FC was observed in cho. supplemented broilers when compared with control birds. These results disagree with those of **Waldroup and Fritts (2005)** who reported that cho. supplementation had no significant effect on FC. Moreover, **Rafeeq *et al.* (2011)** found that the supplementation cho. as choline chloride might have disturbed the ion balance and resulted in lower FI and LBWG. In this respect, **Workel *et al.* (2002)** indicated that a number of factors may influence a hens requirement for cho., for instance age, FI and dietary CP or methionine levels. It is generally accepted that dietary requirement declines with age, possibly associated with an increasing FI.

**Table 3: Effect of dietary energy level on feed intake (FI,g) and feed conversion (FC) of broiler response to choline supplements.**

| Items | | FI, g (age period, days) | | | | FC (age period, days) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 5-11 | 12-23 | 24-42 | 5-42 | 5-11 | 12-23 | 24-42 | 5-42 |
| **Choline (Cho.)%:** | | | | | | | | | |
| **0.00** | | 108.07 | 955.89$^{b}$ | 1947.2$^{a}$ | 3011.5$^{a}$ | 1.25$^{a}$ | 1.92 | 2.18$^{a}$ | 1.97$^{a}$ |
| **0.10** | | 110.25 | 990.10$^{a}$ | 1800.4$^{b}$ | 2903.6$^{b}$ | 1.14$^{b}$ | 1.94 | 1.93$^{b}$ | 1.86$^{b}$ |
| **SEM**[1] | | 0.83 | 9.10 | 20.75 | 27.92 | 0.04 | 0.04 | 0.06 | 0.04 |
| **P-value** | | 0.067 | 0.009 | <0.001 | 0.012 | 0.048 | 0.703 | 0.009 | 0.041 |
| **ME, kcal./Kg (ME):** | | | | | | | | | |
| **Recommended(R)** | | 105.33$^{c}$ | 919.62$^{b}$ | 1824.3$^{b}$ | 2848.5$^{b}$ | 1.13 | 2.03$^{a}$ | 2.03 | 1.91 |
| **R-100** | | 106.52$^{bc}$ | 992.30$^{a}$ | 1957.9$^{a}$ | 3072.4$^{a}$ | 1.17 | 1.79$^{b}$ | 2.07 | 1.88 |
| **R-200** | | 109.75$^{b}$ | 1006.0$^{a}$ | 1826.7$^{b}$ | 2935.5$^{b}$ | 1.20 | 1.87$^{ab}$ | 2.02 | 1.90 |
| **R-300** | | 115.02$^{a}$ | 974.08$^{a}$ | 1886.3$^{b}$ | 2973.9$^{ab}$ | 1.27 | 2.02$^{a}$ | 2.10 | 1.96 |
| **SEM** | | 1.17 | 12.75 | 27.33 | 36.78 | 0.05 | 0.06 | 0.09 | 0.06 |
| **P-value** | | <0.001 | <0.001 | 0.017 | 0.007 | 0.295 | 0.015 | 0.901 | 0.713 |
| **Cho.% × ME (treatments):** | | | | | | | | | |
| **0.00** | **R** | 104.40$^{d}$ | 918.55 | 1993.5$^{ab}$ | 3025.3$^{ab}$ | 1.21 | 2.05 | 2.33 | 2.05 |
| | **R-100** | 102.07$^{d}$ | 988.50 | 2028.3$^{a}$ | 3125.6$^{a}$ | 1.23 | 1.76 | 2.21 | 1.94 |
| | **R-200** | 109.97$^{bc}$ | 968.40 | 1888.4$^{bc}$ | 2955.7$^{ab}$ | 1.20 | 1.88 | 2.12 | 1.96 |
| | **R-300** | 115.84$^{a}$ | 948.10 | 1878.6$^{bc}$ | 2939.5$^{ab}$ | 1.37 | 1.98 | 2.07 | 1.93 |
| **0.10** | **R** | 106.27$^{cd}$ | 920.70 | 1655.1$^{d}$ | 2671.6$^{c}$ | 1.05 | 2.01 | 1.72 | 1.77 |
| | **R-100** | 110.98$^{abc}$ | 996.10 | 1887.4$^{bc}$ | 3019.3$^{ab}$ | 1.11 | 1.83 | 1.93 | 1.83 |
| | **R-200** | 109.54$^{bc}$ | 1043.5 | 1765.0$^{cd}$ | 2915.3$^{b}$ | 1.21 | 1.87 | 1.93 | 1.84 |
| | **R-300** | 114.21$^{ab}$ | 1000.1 | 1894.0$^{bc}$ | 3008.3$^{ab}$ | 1.18 | 2.05 | 2.14 | 1.99 |
| **SEM** | | 1.65 | 18.03 | 38.65 | 52.00 | 0.08 | 0.08 | 0.12 | 0.07 |
| **P-value** | | 0.009 | 0.139 | 0.001 | 0.004 | 0.611 | 0.874 | 0.078 | 0.147 |

**[a–d] Means in a column with different superscripts differ significantly (*P*≤0.05). [1] Pooled SEM**

Dietary ME effect was significant for FI during all periods studied and FC during the period from 12 to 23 days (Table 3). It is clear that, chicks fed R-100 Kcal/Kg diet had significantly higher values of FI during the periods from 24 to 42 and 5 to 42 days, while, chicks fed control diet had significantly lower values of FI during all periods studied (this may be due to, high ambient temperature is very disruptive for broilers which results in reduced FI and consequential depression of growth performance **(Sahin and Kucuk, 2003)** and/or is related to the ability of birds to regulate the energy intake to meet their specific needs **(Hill, 1962).** Chicks fed R-100 Kcal/Kg diet had the best value of FC during the period from 12 to 23 days and those fed control diet had the worst FC during the same period. Similar to the present findings, **Ragab (2013)** concluded that level of ME in broiler diet had a significant effect on FI during all periods studied. **Leeson *et al.* (1996b)** showed that presumably the increased FI is caused by the bird's attempt at maintaining a normal energy intake, but even with a linear increase in FI in response to energy dilution, there was a linear decline in energy intake. **Jackson *et al.* (1982)** also found that male broiler chickens were unable to maintain a constant intake of energy when fed diets of lower energy content. **Summers and Leeson (1984)** showed a comparable effect on energy intake when broilers were fed diets over the range 2700 to 3300 Kcal ME/kg. While, **Giachetto *et al.* (2003)** reported that birds fed with high dietary energy level (3200 Kcal ME/kg) had a lower FI and better FC. Contrary to popular belief, the broiler chicken may not be eating to meet needs of physical satiety, although undoubtedly the bird's voracious appetite does play some role in influencing both feed and energy intake **(Leeson *et al.*, 1996a)**.

Interaction due to level of cho.% x dietary ME Kcal/Kg diet had significantly affected FI during all periods studied except, the period from 12 to 23 days which was insignificantly (P>0.05) affected (Table 3). It is clear that, chicks fed cho. un-supplement diet with R-100 Kcal/Kg diet had significantly higher values of FI during the periods from 24 to 42 and 5 to 42 days (lower value of FI during the period from 5 to 11 days), while, chicks fed control diets with cho. supplement had significantly lower values of FI during the periods from 24 to 42 and 5 to 42 days. Numerically, all dietary treatments improved FC during the periods from 24 to 42 and 5 to 42 days as compared with those fed control diet, but differences were not significant (Table 3). Similar results were observed by **Hunton (1995)** who found that FI was increased as well as FC was improved by low level of energy in the diet. Also, **Oke *et al.* (2003)** reported that high dietary energy levels inhibit FI, and FC was improved when laying hens were fed diet containing 2750 kcal ME/kg compared with the other diets which containing 2650 or 2850 kcal ME/kg. **Harms *et al.* (2000); Bryant *et al.* (2005) and Zou and Wu (2005)** reported that increasing dietary energy or supplementing fat had a significant effect on FI.

Data presented in Table (4) indicate the main effects of cho. was significant (P≤0.01 and P≤0.05) for CPC and CCR during the periods from 5 to 11 and 24 to 42 days and GR during the period from 5 to 11 days of age. As shown in Table 4, cho. supplementation (0.1%) significantly improve CPC and CCR during the periods from 5 to 11 and 24 to 42 days and increase GR during the period from 5 to 11 days of age, as compared with those fed cho. un-supplement diet. Numerically, cho. supplementation (0.1%) improve CPC, CCR and increase GR, PI during the period from 5 to 42 days as compared with those fed cho. un-supplement diet (0.0%), however, these did not reach a level of statistical significance (Table 4). Similar results were observed by **Baranova (1993) and Vogt (1994)** who found that choline supplementation improved growth.

Dietary ME effect was significant for CPC, CCR, GR and PI during the period from 12 to 23 days of age (Table 4). Chicks fed R-100 Kcal/Kg diet had the best values (differences between R-100 and R-200 Kcal/Kg diet were not significant) of CPC, CCR, GR and PI during this period, while, chicks fed control diet had the worst values during the same period. Interaction due to level of cho.% x dietary ME Kcal/Kg diet had insignificantly ($P>0.05$) affected CPC, CCR, GR and PI during all periods studied. Numerically, as shown in Table 4, all dietary treatments improved CCR and PI during the finisher and overall periods studied compared with those fed control diet (but differences were not significant). Similarly, **Leeson *et al.* (1996b)** established that, although energy intake was reduced in response to the reduced energy level of the diet, and although this reduction in energy intake was associated with no change in body weight, the birds fed lower energy diets were much more efficient in converting energy to LBWG. Also, **Leeson *et al.* (1996a)** demonstrate that, although FI increased linearly with decreasing diet energy, birds in all groups consumed essentially the same amount of energy during the trial. On the other hand, because protein levels of all diets remained constant, total protein intake and grams of protein consumed per kg of LBW increased significantly with decreasing diet energy level.

**Slaughter parameters%:** As shown in Table 5, neither cho.% nor interaction between cho.% x dietary ME Kcal/Kg diet had any significant effect on slaughter parameters% (Table 5).

**Table 4: Effect of dietary energy level on crude protein conversion (CPC), caloric conversion ratio (CCR), growth rate (GR) and performance index (PI) of broiler response to choline supplements.**

| Items | | CPC (age period, days) | | | | CCR (age period, days) | | | | GR (age period, days) | | | | PI (age period, days) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5-11 | 12-23 | 24-42 | 5-42 | 5-11 | 12-23 | 24-42 | 5-42 | 5-11 | 12-23 | 24-42 | 5-42 | 5-11 | 12-23 | 24-42 | 5-42 |
| Choline (Cho.)%: | | | | | | | | | | | | | | | | | |
| 0.00 | | 0.294[a] | 0.422 | 0.437[a] | 0.373 | 3.569[a] | 5.800 | 6.725[a] | 5.218 | 0.573[b] | 1.112 | 0.763 | 0.821 | 17.52 | 39.81 | 80.03 | 47.06 |
| 0.10 | | 0.268[b] | 0.427 | 0.386[b] | 0.358 | 3.251[b] | 5.867 | 5.918[b] | 4.984 | 0.618[a] | 1.103 | 0.784 | 0.835 | 19.35 | 38.95 | 89.63 | 49.52 |
| SEM[1] | | 0.01 | 0.01 | 0.01 | 0.01 | 0.11 | 0.13 | 0.20 | 0.09 | 0.01 | 0.01 | 0.02 | 0.01 | 0.75 | 1.70 | 3.56 | 1.58 |
| P-value | | 0.048 | 0.703 | 0.009 | 0.086 | 0.048 | 0.715 | 0.008 | 0.062 | 0.013 | 0.662 | 0.367 | 0.218 | 0.089 | 0.729 | 0.076 | 0.302 |
| ME, kcal./Kg (ME): | | | | | | | | | | | | | | | | | |
| Recommended(R) | | 0.265 | 0.447[a] | 0.405 | 0.365 | 3.399 | 6.449[a] | 6.533 | 5.354 | 0.601 | 1.052[b] | 0.812 | 0.822 | 19.53 | 34.31[b] | 84.42 | 46.61 |
| R-100 | | 0.275 | 0.394[b] | 0.414 | 0.351 | 3.407 | 5.512[b] | 6.475 | 5.007 | 0.600 | 1.149[a] | 0.754 | 0.839 | 19.32 | 45.51[a] | 87.44 | 51.91 |
| R-200 | | 0.283 | 0.412[ab] | 0.405 | 0.366 | 3.382 | 5.576[b] | 6.123 | 5.015 | 0.586 | 1.139[a] | 0.759 | 0.830 | 17.97 | 40.96[ab] | 86.75 | 48.64 |
| R-300 | | 0.299 | 0.444[a] | 0.421 | 0.380 | 3.453 | 5.796[b] | 6.155 | 5.029 | 0.595 | 1.091[ab] | 0.769 | 0.821 | 16.93 | 36.74[b] | 80.69 | 46.01 |
| SEM | | 0.01 | 0.01 | 0.02 | 0.01 | 0.15 | 0.18 | 0.26 | 0.11 | 0.02 | 0.02 | 0.02 | 0.01 | 1.03 | 2.36 | 4.69 | 2.08 |
| P-value | | 0.295 | 0.015 | 0.901 | 0.148 | 0.991 | 0.002 | 0.661 | 0.152 | 0.933 | 0.003 | 0.281 | 0.626 | 0.264 | 0.009 | 0.778 | 0.318 |
| Cho.% × ME (treatments): | | | | | | | | | | | | | | | | | |
| 0.00 | R | 0.284 | 0.451 | 0.466 | 0.381 | 3.643 | 6.513 | 7.512 | 5.617 | 0.578 | 1.049 | 0.774 | 0.818 | 18.05 | 34.48 | 72.63 | 43.42 |
| | R-100 | 0.288 | 0.386 | 0.443 | 0.357 | 3.572 | 5.397 | 6.916 | 5.096 | 0.564 | 1.177 | 0.735 | 0.824 | 18.43 | 47.64 | 83.27 | 51.74 |
| | R-200 | 0.281 | 0.414 | 0.424 | 0.372 | 3.361 | 5.595 | 6.418 | 5.109 | 0.580 | 1.127 | 0.765 | 0.827 | 17.94 | 39.44 | 80.47 | 46.01 |
| | R-300 | 0.321 | 0.436 | 0.414 | 0.383 | 3.702 | 5.695 | 6.054 | 5.050 | 0.572 | 1.096 | 0.779 | 0.816 | 15.68 | 37.66 | 83.76 | 47.08 |
| 0.10 | R | 0.246 | 0.442 | 0.344 | 0.348 | 3.154 | 6.386 | 5.554 | 5.091 | 0.625 | 1.055 | 0.850 | 0.826 | 21.02 | 34.14 | 96.22 | 49.80 |
| | R-100 | 0.262 | 0.403 | 0.386 | 0.346 | 3.242 | 5.628 | 6.034 | 4.917 | 0.637 | 1.121 | 0.773 | 0.855 | 20.21 | 43.37 | 91.62 | 52.08 |
| | R-200 | 0.285 | 0.411 | 0.385 | 0.360 | 3.403 | 5.557 | 5.828 | 4.921 | 0.592 | 1.151 | 0.754 | 0.832 | 17.99 | 42.49 | 93.04 | 51.27 |
| | R-300 | 0.278 | 0.451 | 0.428 | 0.377 | 3.204 | 5.897 | 6.257 | 5.007 | 0.619 | 1.086 | 0.759 | 0.825 | 18.18 | 35.82 | 77.63 | 44.94 |
| SEM | | 0.02 | 0.02 | 0.02 | 0.01 | 0.22 | 0.25 | 0.38 | 0.15 | 0.03 | 0.03 | 0.03 | 0.01 | 1.46 | 3.28 | 6.63 | 2.94 |
| P-value | | 0.611 | 0.874 | 0.078 | 0.713 | 0.620 | 0.873 | 0.065 | 0.538 | 0.683 | 0.520 | 0.388 | 0.844 | 0.794 | 0.758 | 0.223 | 0.499 |

[a–b] Means in a column with different superscripts differ significantly ($P \leq 0.05$). [1] Pooled SEM

Table 5: Effect of dietary energy level on slaughter parameters% of broiler response to choline supplements.

| Items | | Live body weight (g) | Slaughter parameters% | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Heart | Liver | Gizzard | Spleen | Total giblets | Abdominal fat | Bursa | Thymus | Breast meat | Rear meat | Carcass weight after evisceration | Dressing |
| Choline (Cho.)%: | | | | | | | | | | | | | | |
| 0.00 | | 1689.3 | 0.457 | 2.45 | 1.37 | 0.175 | 4.45 | 1.59 | 0.107 | 0.349 | 86.08 | 83.42 | 61.15 | 65.60 |
| 0.10 | | 1709.4 | 0.417 | 2.39 | 1.39 | 0.127 | 4.32 | 1.36 | 0.144 | 0.367 | 86.85 | 84.39 | 61.46 | 65.78 |
| SEM[1] | | 48.26 | 0.02 | 0.08 | 0.06 | 0.02 | 0.07 | 0.15 | 0.01 | 0.05 | 0.64 | 0.48 | 0.56 | 0.57 |
| P-value | | 0.776 | 0.110 | 0.601 | 0.840 | 0.052 | 0.188 | 0.30 | 0.079 | 0.799 | 0.418 | 0.194 | 0.700 | 0.826 |
| ME, kcal./Kg (ME): | | | | | | | | | | | | | | |
| Recommended(R) | | 1620.5 | $0.511^{a}$ | 2.50 | 1.50 | 0.140 | $4.65^{a}$ | 1.40 | 0.106 | 0.329 | 86.11 | 83.11 | 61.29 | 65.94 |
| R-100 | | 1729.8 | $0.404^{b}$ | 2.21 | 1.36 | 0.149 | $4.13^{c}$ | 1.76 | 0.112 | 0.381 | 86.28 | 84.46 | 61.63 | 65.76 |
| R-200 | | 1751.8 | $0.416^{b}$ | 2.58 | 1.32 | 0.162 | $4.48^{ab}$ | 1.35 | 0.136 | 0.303 | 88.48 | 84.61 | 61.91 | 66.39 |
| R-300 | | 1695.3 | $0.417^{b}$ | 2.38 | 1.35 | 0.154 | $4.30^{bc}$ | 1.38 | 0.147 | 0.421 | 85.00 | 83.46 | 60.39 | 64.69 |
| SEM | | 68.25 | 0.02 | 0.11 | 0.09 | 0.02 | 0.09 | 0.21 | 0.02 | 0.07 | 0.90 | 0.68 | 0.79 | 0.81 |
| P-value | | 0.573 | 0.032 | 0.184 | 0.516 | 0.904 | 0.019 | 0.51 | 0.412 | 0.643 | 0.125 | 0.380 | 0.576 | 0.528 |
| Cho.% × ME (treatments): | | | | | | | | | | | | | | |
| 0.00 | R | 1586.0 | 0.521 | 2.51 | 1.46 | 0.147 | 4.65 | 1.88 | 0.063 | 0.353 | 85.88 | 83.82 | 61.51 | 66.16 |
| | R-100 | 1725.0 | 0.411 | 2.27 | 1.45 | 0.185 | 4.32 | 1.64 | 0.104 | 0.329 | 84.64 | 83.38 | 60.03 | 64.35 |
| | R-200 | 1793.5 | 0.449 | 2.51 | 1.25 | 0.174 | 4.38 | 1.18 | 0.130 | 0.345 | 88.06 | 82.96 | 62.77 | 67.15 |
| | R-300 | 1652.5 | 0.448 | 2.50 | 1.34 | 0.194 | 4.47 | 1.64 | 0.130 | 0.369 | 85.75 | 83.55 | 60.28 | 64.75 |
| 0.10 | R | 1655.0 | 0.500 | 2.49 | 1.53 | 0.132 | 4.65 | 0.91 | 0.149 | 0.306 | 86.33 | 82.39 | 61.06 | 65.71 |
| | R-100 | 1734.5 | 0.398 | 2.15 | 1.28 | 0.113 | 3.94 | 1.87 | 0.121 | 0.432 | 87.93 | 85.54 | 63.23 | 67.17 |
| | R-200 | 1710.0 | 0.383 | 2.65 | 1.40 | 0.149 | 4.58 | 1.52 | 0.143 | 0.260 | 88.90 | 86.27 | 61.05 | 65.63 |
| | R-300 | 1738.0 | 0.386 | 2.26 | 1.37 | 0.113 | 4.12 | 1.12 | 0.164 | 0.472 | 84.26 | 83.37 | 60.50 | 64.62 |
| SEM | | 96.52 | 0.03 | 0.16 | 0.12 | 0.03 | 0.13 | 0.29 | 0.03 | 0.10 | 1.28 | 0.97 | 1.11 | 1.14 |
| P-value | | 0.816 | 0.779 | 0.68 | 0.63 | 0.622 | 0.145 | 0.154 | 0.535 | 0.685 | 0.377 | 0.135 | 0.233 | 0.331 |

$^{a–c}$ Means in a column with different superscripts differ significantly ($P \leq 0.05$). [1] Pooled SEM

Numerically, cho. supplementation (0.1%) decrease heart, liver, spleen, total giblets and abdominal fat%, while, increase gizzard, bursa, thymus breast meat, rear meat, carcass weight after evisceration and dressing as compared with those fed cho. un-supplement diet, however, these did not reach a level of statistical significance (Table 5). These results are in harmony with those obtained by **Harms and Russell (2002) and Fouladi *et al.* (2011)** who demonstrated that the presence of choline chloride supplements in diets decrease the livers, spleen and heart weights in the poultry. They are recognize these effects in relationship with the donor methyl group by choline and there are contributed in the fats metabolism in these organs. On the other hand, choline is essential for the fat metabolism in the liver where it is part of lipoproteins that transport lipids between tissues and organs and as a precursor for acetyl choline synthesis **(Fouladi *et al.,* 2011).** Also, dietary choline chloride supplementation use in diets, decrease significantly abdominal fat, but, no improvement effects on the gizzard, meat yield and carcass weight in poultry **(Hassan *et al.,* 2005 and Waldroup and Fritts, 2005).** Moreover, **Waldroup *et al.* (2006)** reported that, no significant effects on dressing% and significant improvements in breast meat yield were frequently observed when addition of 1000 mg of cho./kg over the birds fed the unsupplemented diets at 42, 49, or 56 days of age. While, **Waldroup and Fritts (2005)** demonstrated that addition of 1000 mg/kg of cho. significantly improved breast meat yield at 42 d but not at 49 days.

Concerning the dietary ME (Table 5), no significant differences due to level of ME on slaughter parameters%, except, heart and total giblets% which were significantly ($P \leq 0.05$) affected. It can be concluded that, chicks fed control diet had higher heart and total giblets% while, chicks fed R-100 Kcal/Kg diet had lower values (differences between R-100 and R-300 Kcal/Kg diet were not significant). In this response, **Linn *et al.,* (2006)** stress responses and liver and heart damage occur in broiler chickens that are acutely exposed to high temperatures**.** Thus it has become necessary to avoid heat stress in order to prevent unnecessary suffering and reduced productivity. As occurred with the current study, **Giachetto *et al.* (2003)** found that abdominal fat pad was not affected by energy levels in broilers diet. Further, **Leeson *et al.* (1996a)** reported that, weight of carcasses, breast meat yield and breast meat as a percentage of carcass weight were unaffected by diet energy level, while, absolute and proportional weight of the abdominal fat pad decreased linearly with a decrease in diet energy level. Diet dilution and physical feed restriction of older broilers can be used to reduce carcass fatness, but that carcass weight is adversely affected **(Leeson *et al.*, 1992)**.

**Blood constituents:** As shown in Table 6, no significant (P>0.05) differences were detected in blood constituents due to cho.%, dietary ME Kcal/Kg diet and interaction between cho.% x dietary ME. Numerical improvements in white blood cells count (WBCs), red blood cells count (RBCs), hemoglobin (HGB, g/dL), hematocrit (HCT%), mean corpuscular volume (MCV) and mean corpuscular hemoglobin **(**MCH) were frequently observed when cho. was added and all experimental treatments improved WBCs (P>0.05) as compared with control diet however, these did not reach a level of statistical significance. Similar to the present findings, choline-deficient pigs have reduced LBWG, decreased RBCs , HCT% and HGB **(NRC, 1998**).

**Economical efficiency (EEf):** Results in Table 7 showed that, EEf values during the period from 5 to 42 days of age improved in chicks fed all experimental diets as compared with those fed the control diet. Chicks fed cho. un-supplement diet with R-300 Kcal/Kg diet had the best economical and relative efficiency values being 2.206 and 133.28%, respectively, followed by chicks fed cho. supplement (0.1%) diet with R-200 Kcal/Kg diet (2.175 and 131.45%, respectively), then chicks fed cho. supplement (0.1%) diet with R-100 Kcal/Kg diet (2.053 and 124.06%, respectively) as compared with those fed the control diet (the lowest corresponding values, being 1.655 and 100.0%, respectively). The relative efficiency varied between 100.0% to 133.28%, which is of minor importance relative to other factors of production.

**Mortality rate%:** Data in Table 7 showed that the percentage of mortality was 4.76% in chicks fed diets 1, 2, 5, 6 and 7. However, the percentage of mortality was zero% in chicks fed the other experimental diets. It appears that mortality% was within normal limits and not related to experimental treatments studied.

**Table 6: Effect of dietary energy level on some blood parameters of broiler response to choline supplements.**

| Items | | White blood cells count ($10^3/mm^3$) | Red blood cells count ($10^6/mm^3$) | Hemoglobin (g/dL) | Hematocrit (HCT)% | Mean corpuscular volume (MCV) $\mu^2$ | Mean corpuscular hemoglobin (MCH) µµg | Mean corpuscular hemoglobin concentration (MCHC)% |
|---|---|---|---|---|---|---|---|---|
| **Choline (Cho.)%:** | | | | | | | | |
| **0.00** | | 14.35 | 2.381 | 10.31 | 33.17 | 144.35 | 44.78 | 31.05 |
| **0.10** | | 14.85 | 2.412 | 10.54 | 34.16 | 146.84 | 45.04 | 30.73 |
| **SEM**[1] | | 0.39 | 0.11 | 0.26 | 0.95 | 1.47 | 0.67 | 0.24 |
| **P-value** | | 0.39 | 0.846 | 0.559 | 0.482 | 0.264 | 0.794 | 0.358 |
| **ME, kcal./Kg (ME):** | | | | | | | | |
| **Recommended(R)** | | 13.41 | 2.350 | 10.38 | 33.98 | 149.58 | 45.50 | 30.50 |
| **R-100** | | 15.28 | 2.502 | 10.85 | 34.48 | 143.10 | 44.39 | 31.11 |
| **R-200** | | 14.44 | 2.405 | 10.19 | 33.34 | 143.58 | 44.26 | 30.74 |
| **R-300** | | 15.26 | 2.330 | 10.29 | 32.86 | 146.10 | 45.48 | 31.21 |
| **SEM** | | 0.55 | 0.15 | 0.37 | 1.34 | 2.07 | 0.95 | 0.34 |
| **P-value** | | 0.127 | 0.859 | 0.624 | 0.836 | 0.186 | 0.688 | 0.455 |
| **Cho.% × ME (treatments):** | | | | | | | | |
| **0.00** | **R** | 12.56 | 2.445 | 10.85 | 35.11 | 147.07 | 45.20 | 30.81 |
| | **R-100** | 15.35 | 2.460 | 10.50 | 33.90 | 143.61 | 44.36 | 30.92 |
| | **R-200** | 14.44 | 2.350 | 9.72 | 32.16 | 143.58 | 44.03 | 30.52 |
| | **R-300** | 15.03 | 2.270 | 10.17 | 31.50 | 143.13 | 45.52 | 31.98 |
| **0.10** | **R** | 14.27 | 2.255 | 9.90 | 32.85 | 152.10 | 45.79 | 30.19 |
| | **R-100** | 15.21 | 2.543 | 11.19 | 35.06 | 142.59 | 44.41 | 31.31 |
| | **R-200** | 14.43 | 2.460 | 10.66 | 34.52 | 143.58 | 44.49 | 30.97 |
| | **R-300** | 15.48 | 2.390 | 10.40 | 34.21 | 149.06 | 45.45 | 30.44 |
| **SEM** | | 0.78 | 0.22 | 0.53 | 1.90 | 2.93 | 1.34 | 0.48 |
| **P-value** | | 0.637 | 0.872 | 0.348 | 0.570 | 0.571 | 0.993 | 0.198 |

[1] Pooled SEM

**It would be concluded that,** no simple guideline can exist with regard to formulation of broiler diets suitable for the different seasons and geographical locations or for the selection of the economically optimal combination of nutrition and environmental temperature. So, the poultry producer must know the nutritional requirements specifically under summer conditions. Therefore, dietary ME can be reduced from the recommended level up to 300 Kcal/Kg diet and supplement these diets with choline specifically under summer conditions without affecting Ross broiler performance.

**Table 7: Effect of dietary energy level on economical efficiency (EEf) and mortality rate% of broiler response to choline supplements.**

| Items | Choline% | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.00 | | | | 0.10 | | | |
| ME, kcal./Kg | R* | R-100 | R-200 | R-300 | R | R-100 | R-200 | R-300 |
| Treatment | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Economical efficiency(EEf)** | | | | | | | | |
| $a_1$ | 0.1044 | 0.1021 | 0.1100 | 0.1158 | 0.1063 | 0.1110 | 0.1095 | 0.1142 |
| $b_1$ | 244.98 | 236.11 | 227.32 | 218.25 | 247.98 | 239.11 | 230.32 | 221.25 |
| $a_1 \times b_1=c_1$ | 25.575 | 24.099 | 24.998 | 25.282 | 26.352 | 26.537 | 25.228 | 25.269 |
| $a_2$ | 0.9185 | 0.9885 | 0.9684 | 0.9481 | 0.9207 | 0.9961 | 1.0435 | 1.0001 |
| $b_2$ | 246.72 | 238.10 | 228.28 | 218.61 | 249.72 | 241.10 | 231.28 | 221.61 |
| $a_2 \times b_2=c_2$ | 226.62 | 235.36 | 221.06 | 207.26 | 229.92 | 240.16 | 241.34 | 221.63 |
| $a_3$ | 1.9935 | 2.0283 | 1.8884 | 1.8786 | 1.6551 | 1.8874 | 1.7650 | 1.8940 |
| $b_3$ | 237.87 | 227.94 | 218.09 | 209.59 | 240.87 | 230.94 | 221.09 | 212.59 |
| $a_3 \times b_3=c_3$ | 474.19 | 462.34 | 411.84 | 393.73 | 398.66 | 435.88 | 390.22 | 402.64 |
| $c_1+c_2+c_3=c_{total}$ | 726.39 | 721.79 | 657.90 | 626.27 | 654.93 | 702.57 | 656.79 | 649.53 |
| d | 1.4835 | 1.644 | 1.5289 | 1.5444 | 1.5143 | 1.6501 | 1.6043 | 1.5172 |
| e | 1300.0 | 1300.0 | 1300.0 | 1300.0 | 1300.0 | 1300.0 | 1300.0 | 1300.0 |
| d x e=f | 1928.6 | 2137.2 | 1987.6 | 2007.7 | 1968.6 | 2145.1 | 2085.6 | 1972.4 |
| $f- c_{total} =g$ | 1202.2 | 1415.4 | 1329.7 | 1381.4 | 1313.7 | 1442.6 | 1428.8 | 1322.8 |
| $g/ c_{total}$ | 1.6550 | 1.9610 | 2.0211 | 2.2058 | 2.0058 | 2.0533 | 2.1754 | 2.0366 |
| r | 100.00 | 118.49 | 122.12 | 133.28 | 121.20 | 124.06 | 131.45 | 123.06 |
| **Mortality rate%** | | | | | | | | |
| Total number of chicks at the beginning of Exp. | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| Number of dead birds | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| Mortality rate% | 4.76 | 4.76 | 0.00 | 0.00 | 4.76 | 4.76 | 4.76 | 0.00 |

* Recommended

$a_1, a_2$ and $a_3$ ……….average feed intake (Kg/bird) during the periods of starter, grower and finisher, respectively.
$b_1, b_2$ and $b_3$ …...… price/Kg feed (P.T.) during the periods of starter, grower and finisher, respectively (based on average local market price of diets during the experimental time).
$c_1, c_2$ and $c_3$ …….. Feed cost (P.T.) during the periods of starter, grower and finisher, respectively.
Total feed cost (P.T.) = $c_{total} = c_1+c_2+c_3$
Average LBWG (Kg/ bird) d
Price / Kg live weight (P.T.) e……..…(according to the local market price at the experimental time).
Total revenue (P.T.) = d x e = f
Net revenue (P.T.) = $f - c_{total} = g$
Economical efficiency = $(g/c_{total})$ ……(net revenue per unit feed cost).
Relative efficiency r……...(assuming that economical efficiency of the control group (1) equals 100).

## REFERENCES


A.O.A.C. (1990). Association of Official Analytical Chemists, Official Methods of Analysis. 15th Edition, Washington, D.C, USA.

Albright, C. D., K. A. daCosta, C.N. Craciunescu, E. Klem, M.H. Mar and S. H. Zeisel (2005) Regulation of choline deficiency apoptosis by epidermal growth factor in CWSV-1 rat hepatocytes. Cell Physiol. Biochem. 15(1-4): 59-68.

Baghel, R. P. S. and K. Pradhan (1990). Effect of season and age on the utilization of metabolizable energy by broilers. Indian. J. Anim. Sci., 60: 239-242.

Baranova, G. (1993). Choline in diets for broiler chickens. Poult. Abst. pp. 019-00368

Bollengier, L. S., M.A. Mitchell, D.B. Utomo, P.E.V. Williams and C.C. Whitehead (1998). Influence of high dietary vitamin E supplementation on egg production and plasma characteristics in hens subjected to heat stress. Br. Poult. Sci. 39: 1, 106-112.

Bryant, M., G. Wu and D. S. Roland (2005) Optimizing dietary energy for profits and performance of two strains of white leghorns. Page 23 in: International Poultry Scientific Forum Abstracts, Atlanta, GA, USA.

Burg, M. B. (1995). Molecular basis of osmotic regulation. Am J Physiol 268:F983-F996.

Cerci, I. H., P. Tatli, M. A. Azman and N. Birben (2003). The effect of restricted feed on feed intake, egg production and feed conversion in pullets. Indian Vet. J. 80, 1153–1157.

Chapman, B., D. Salmon, C. Dyson and K. Blackley (2005). Triticale Production and Utilization Manual. Alberta Agriculture, Food & Rural Development (AAFRD).

Cromwell, G. L., M. D. Lindemann, J. R. Randolph, H. J. Monegue, K. M. Laurent and G. R. Parker (1999). Efficacy of betaine as a carcass modifier in finishing pigs fed normal and reduced energy diets. J. Anim. Sci. 77(Suppl. 1):179. (Abstr.)

Daghir, N. J. (1983). Effect of lysine and methionine supplementation of low protein roaster diets fed after six weeks of age. Poult. Sci. 62, 572-575.

Dilger, R.N., T. A. Garrow and D. H. Baker (2007). Betaine can partially spare choline in chicks but only when added to diets containing a minimal level of choline. J.Nutr. 137:2224-2228.

Duncan, D.B. (1955). Multiple range and multiple F tests. Biometrics, 11: 1-42.

Dunlevy, L. P. E., L. S. Chitty, K. A. Burren, K. Doudney, T. S. Mikic, P. Stanier, R. Scott, A. J. Copp and N. D. E. Greene (2006). Excess methionine suppresses the methylation cycle and inhibits neural tube closure in mouse embryos. FEBS Letters, 11, 2803-2807.

Dunshea, F. R., D. J. Cadogan and G. G. Partridge (2009). Dietary betaine and ractopamine combine to increase lean tissue deposition in finisher pigs, particularly gilts. Anim. Prod. Sci. 49, 65-70.

Emam, R. M. S. (2010). A study of substituting yellow corn by triticale grains on productive performance of two broiler strains. Ph.D. Thesis, Fac. Agric., Fayoum University, Egypt.

Emam, R. M. S. (2013). Effect of phytase supplementation on performance of broiler fed triticale diets varying in their phosphorus content. Egyptian J. Nutrition and Feeds, 16: (in press)

Finkelstein, J. D. (2000). Homocysteine: a history in progress. Nutr Rev. 58, 193-204.

Fouladi, P., S. D. Nobar, R. Ahmadzade, A. A. Shahriar and H. A. Abolfazl (2011). Effect of Choline Chloride Supplement on the Internal Organs and Carcass Weight of Japanese quail. Annals of Biological Research, 2 (5) :485-491.

Garcia, N. M., G.M. Pesti and R.I. Bakalli (2000). Influence of dietary protein level on the broiler chickens response to methionine and betaine supplements. Poult. Sci., 79: 1478-1484.

Garlich, J. D. (1979). Regulation of lipid metabolism in avian species. Federation Proceedings, 38: 2616-2623.

Garrow, T. A. (2007). Choline. In: Zempleni J, Rucker RB, McCormick DB, Suttie JW, editors. Handbook of vitamins. 4th ed. Taylor & Francis Group, LLC: CRC Press; pp. 459–487.

Giachetto, P. F., E. N. Guerreiro, J. A. Ferro, M. I. T. Ferro, R. L. Furlan and M. Macari (2003). Performance and hormonal profile in broiler chickens fed with different energy levels during post restriction period. Pesq. agropec. bras., Brasilia, 38, 6: 697-702.

Harms, R. H. and G. B Russell (2002). Betaine Does Not Improve Performance of Laying Hens when the Diet Contains Adequate Choline. Poultry Sci., 81: 99-101.

Harms, R. H., G.B. Russell and D.K. Sloan (2000) Performance of four strains of commercial layers with major changes in dietary energy. J. Appl. Poult. Res 9: 535-541.

Hassan, R. A., Y. A. Attia and E.H. El-Ganzory (2005). Growth, carcass quality and serum constituents of slow growing chicks as affected by betaine addition to diets containing 1.Different levels of choline. Int. J. Poult. Sci., 4: 840-850.

Hermes, J. C. and R. C. Johnson (2004). Effects of feeding various levels of triticale var. bogo in the diet of broiler and layer chickens. J. Appl. Poult. Res., 13: 667 - 672.

Hill, F. W. (1962). Some aspects of the physiology of food intake and digestion in chickens. In Nutrition Of Pigs And Poultry. J. T. Morgan and D.Lewis, Butterworth, London.

Hocking, P.M., R. Bernard and G.W. Robertson (2002). Effects of low dietary protein and different allocations of food during rearing and restricted feeding after peak rate of lay on egg production, fertility and hatchability in female broiler breeders. Br. Poult. Sci., 43: 94-103.

Hoffman, E. and J.M. Gwin (1954). Successful Broiler Growing. Ed. M. Morris, Wat Publishing Co.

Hoffmann, L., R. Schiemann and M. Klein (1991). Energy metabolism of growing broilers in relation to environmental temperature. Archives. Anim. Nutr., 41: 167-181.

Hunton, H. (1995). Poultry Production. Onario, Canada, pp 53 – 118.

Jackson, S., J. D. Summers and S. Leeson (1982). The response of male broilers to varying levels of dietary protein and energy. Nutr. Rep. Int. 25:601-606.

Jadhav, N. V., V. Nagbhushana, S. Maini and S. M. Kartikesh (2008). An Evaluation of comparative effects of feeding synthetic and herbal choline on broiler performance، nutrient balance and serum activities. Veterinary World, Vol.1(10): 306-309.

Janssen, W. M. M. A. (1989). European Table of Energy Values for Poultry Feedstuffs. 3rd ed. Beekbergen, Netherlands: Spelderholt Center for Poultry Research and Information Services.

Kidd, M. T., P. R. Ferket and J.D. Garlich (1997). Nutritional and osmoregulatory functions of betaine . Worlds Poult. Sci., 53: 125-139.

Leeson, S., J. D. Summers and L. J. Caston (1992). Response of broilers to feed restriction or diet dilution in the finisher period. Poult. Sci., 71: 2056-2064.

Leeson, S., L. Caston and J. D. Summers (1996a) Broiler Response to Diet Energy. Poult. Sci., 75: 529-535

Leeson, S., L. Caston and J. D. Summers (1996b) Broiler Response to Energy or Energy and Protein Dilution in the Finisher Diet. Poult. Sci., 75: 522-528

Linn, H., H. O. Jiao, J. Buyse and E. Decuypere (2006). Strategies for preventing heat stress in poultry. World's Poult. Sci. J., 62: 71–86.

Lowry, K. R., Q. A. Izuierdo and D. H. Baker (1987). Efficiency of betaine relative to choline as a dietary methyl donor. Poultry Sci. 66 (Suppl. 1):135. (Abstr.).

Mahmoud, K. Z., F.W. Edens, E.J. Eisen and G.B. Havenstein (2003). Effect of ascorbic acid and acute heat exposure on heat shock protein 70 expression by young white leghorn chickens. Comparative Biochemistry and Physiology 136, 329–335.

Maurice, D. V., J. E. Jones, S. F. Lightsey, J. F. Rhoades and K. T. Hsu (1989). Chemical composition and nutritive value of triticale (Florida 201) for broiler chickens. Appl. Agric. Res., 4: 243–247.

McDowell, L. R. (2000). Vitamins In Animal And Human Nutrition, Second Edition, Iowa State University Press. ISBN 0-8138-2630-6, pp. 577.

National Research Council, NRC (1994). Nutrient Requirements of Poultry. 9th revised edition. National Academy Press. Washington, D.C., USA.

National Research Council, NRC (1998). Nutrient requirements of swine, 10th revised ed. Washington, DC, USA, National Academy Press.

Niculescu, M. D., C. N. Craciunescu and S. H. Zeisel (2006). Dietary Choline Deficiency Alters Global and Gene-specific DNA Methylation in the Developing Hippocampus of Mouse Fetal Brains. FASEB Journal: Official Publication of the Federation of American Societies for Experimental Biology 20, 1: 43–49.

North, M. O. (1981). Commercial Chicken Production Manual, 2nd Edition. AVI Publishing Company Inc, USA.

Oke, U. K., U. Herbert and A. H. Akinmutimi (2003). Early lay characteristics and hematology of pearl Guinea fowls as influenced by dietary protein and energy levels. Inter. J. Poult. Sci., 2:128-132.

Pogribny, I. P., S. A. Ross, C. Wise, M. Pogribna, E. A. Jones, V. P. Tryndyak, S. J. James, Y. P. Dragan and L. A. Poirier (2006). Irreversible Global DNA Hypomethylation as a Key Step in Hepatocarcinogenesis Induced by Dietary Methyl Deficiency. Mutation Research 593, no. 1–2: 80–87.

Rafeeq, M., T. N. Pasha, M. M. Tariq and M. A. Bajwa (2011). Performance of broiler chicken in early life on methionine deficient feed with added choline and betaine. Int. J. Livest. Prod. 2 (9): 142-144.

Ragab, M. S. (2013). Impact of betaine supplementation to triticale diets varying in their metabolizable energy content on broiler performance during summer season. Egyptian J. Nutrition and Feeds, 16: 113-129.

Sahin, K. and O. Kucuk (2003). Heat stress and dietary vitamin supplementation of poultry diets. Nutrition Abstracts and Reviews. Series B: Livestock Feeds and Feeding, 73: 41R–50R.

Sahin, K., O. Kucuk, A. Hayiril, and S. Prasad (2009). Role of dietary Zinc in heat stressed poultry. Poult. Sci., 88: 217-2183.

Sahin, K., M. Onderci, N. Sahin, M. F. Gursu, F. Khachik and O. Kucuk (2006). Effects of lycopene supplementation on antioxidant status, oxidative stress, performance and carcass characteristics in heat-stressed Japanese quail. J. Thermal Biol. 31, 307–312.

Schrama, J. W., M. J. W. Heetkamp, P. H. Simmins and W. J. J. Gerrits (2003). Dietary betaine supplementation affects energy metabolism of pigs. J. Anim. Sci., 81:1202–1209.

Slagter, P. J. and P.W. Waldroup (1990). Calculation and evaluation of energy: amino acid ratios for the egg-production type hen. Poult. Sci., 69: 1810-1822.

Summers, J. D. and S. Leeson (1984). Influence of dietary protein and energy level on broiler performance and carcass composition. Nutr. Rep. Int. 29:757-767.

Vogt. H. (1994). Can methionine be partially replaced with choline in broiler diet? Poult. Abst., 20(9): 3385.

Waldroup, P.W. and C. A. Fritts (2005) Evaluation of separate and combined effects of choline and betaine in diets for male broilers. Int. J. Poult. Sci. 4: 442-448.

Waldroup, P.W., M. A. Motl, F. Yan and C.A. Fritts (2006). Effects of Betaine and choline on response to methionin supplementation to Broiler diets formulated to industry standards. J. Appl. Poult. Res., 15: 56-71.

Wang, Y. Z., Z. R. Xu and G. Feng (2004). The effect of betaine and DL- methionine on growth performance and carcass characteristics in meat ducks. Anim. Feed Sci. Technol., 116: 151-159.

Workel, H. A., T. Keller, A. Reeve and A. Lauwaerts (2002) Choline-the rediscovered vitamin for poultry. Feed Additive in Poultry.

Wray, C. D., F. I. Fernandez, E. Virtanen, N.C. Steele and T.J. Caperna (2004). Betaine improves growth, but does not induce whole body or hepatic palmitate oxidation in swine (Sus scrofa domestica). Comp. Biochem. Physiol. A 137, 131-140.

Wu, G., and A. Davis (2005). Interrelationship among methionine, choline, and betaine in channel catfish, Ictalurus punctatus. J. World Aquac. Soc. 36, 337–345.

Younis, D.T. (2007). Effect of adding vitamin C to drinking water to reduce the negative effect of heat stress in some productive performance of broiler chickens. Rafidain Agric. J., 4: 47-53.

Zeisel, S.H. and K. A. daCosta (2009). Choline: an essential nutrient for public health. Nutr Rev 2009;67(11):615-23.

Zeisel, S. H., K. A. daCosta, P. D. Franklin, E. A. Alexander, J. T. Lamont, N. F. Sheard and A. Beiser (1991). Choline, an essential nutrient for humans. FASEB J. 5:2093-2098.

Zou, S.G. and Y.Z. Wu (2005) Effects of supplemental fat on performance of laying hens. Int. J. Poult. Sci 4: 998-1000

## الملخص العربي

## تأثير مستوي الطاقة علي استجابة بداري التسمين لإضافة الكولين خلال فصل الصيف

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**معهد بحوث الإنتاج الحيواني- [٢]مركز البحوث الزراعية- الدقي- الجيزة- مصر**

إجريت التجربة في محطة بحوث الدواجن بالعزب-فيوم وذلك خلال الفترة من شهر يونيو إلى أغسطس لسنة ٢٠١١. كان العدد الإجمالي ١٦٨ كتكوت غير مجنس من سلالة روس وغذيت الكتاكيت عمر يوم ولمدة ٤ أيام علي عليقة المقارنة.وكانت التجربة لدراسة تأثير إضافة مستويين من الكولين (صفر و٠.١٠ %) إلي العليقة وكل منها مع أربع

مستويات من الطاقة الممثلة (المستوي الموصي به، المستوي الموصي به – ١٠٠ ، -٢٠٠ ، -٣٠٠ كيلو كالوري/كيلو جرام عليقة) في نظام عاملي ٢x٤ للحصول علي ٨ معاملات غذائية علي أداء بداي التسمين.

**وتم تلخيص النتائج المتحصل عليها كما يلي :**

**الأداء الإنتاجي**: لم يؤثر إضافة الكولين، مستوي الطاقة ولا التداخل بين مستوي الطاقة والكولين علي وزن الجسم ووزن الجسم المكتسب خلال الفترة من ٥–٤٢ يوم. كان هناك تأثير معنوي للكولين علي كمية الغذاء المستهلكة وكفاءة تحويل الغذاء خلال الفترة من ٥–٤٢ يوم، فانخفضت كمية الغذاء المستهلكة وتحسنت كفاءة تحويل الغذاء نتيجة لإضافة الكولين بنسبة ٠.١٠% خلال الفترة السابقة عند مقارنتها بتلك المغذاة علي بالعليقة غير المضاف إليها كولين. كان هناك تأثير معنوي لمستوي الطاقة الممثلة والتداخل بين الكولين ومستوي الطاقة بالكيلو كالوري/كيلو جرام عليقة علي كمية الغذاء المستهلكة خلال الفترة من ٥–٤٢ يوم. ويتضح من ذلك أن الكتاكيت المغذاه علي عليقة تحوي المستوي الموصي به - ١٠٠ كيلو كالورى طاقة ممثلة/كيلو جرام عليقة كانت الاعلي معنويا في كمية الغذاء المستهلكة (كان للكتاكيت المغذاه علي عليقة المقارنة أقل قيم) خلال نفس الفترة. لم يكن هناك أي تأثير معنوي للتداخل بين الكولين% ومستوي الطاقة بالكيلو كالوري/كيلو جرام عليقة علي كفاءة تحويل البروتين، كفاءة تحويل الطاقة، ومعدل النمو ومعامل الأداء الإنتاجي خلال الفترة من ٥-٤٢ يوم.

**قياسات الذبيحة% وقياسات الدم:** لم يكن هناك أي تأثير معنوي لأي من الكولين% او للتداخل بين الكولين% ومستوي الطاقة بالكيلو كالوري/كيلو جرام عليقة علي قياسات الذبيحة% وقياسات الدم ، إيضاً لم يكن هناك أي تأثير معنوي لمستوي الطاقة الممثله بالكيلو كالوري/كيلو جرام عليقة علي قياسات الدم.

**الكفاءة الاقتصادية:** تحسنت قيم الكفاءة الاقتصادية والنسبية للكتاكيت المغذاه علي كل المعاملات التجريبية خلال الفترة من ٥–٤٢ يوم من العمر عند مقارنتها بتلك المغذاه علي عليقة المقارنة (فكانت أحسن قيمة للكفاءة الاقتصادية والنسبية للكتاكيت المغذاه علي عليقة المقارنة -٣٠٠ كيلو كالوري/كيلو جرام عليقة وغير المضاف إليها كولين)

**يمكن التوصية** بخفض طاقة العليقة الممثلة عن المستوي الموص به بمعدل 300 كيلو كالورى/كيلو جرام عليقة مع إضافة الكولين لسلالة الروس المرباه خلال فترة الصيف.