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.***

IMPACT OF BETAINE SUPPLEMENTATION TO TRITICALE DIETS VARYING IN THEIR METABOLIZABLE ENERGY CONTENT ON BROILER PERFORMANCE 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. At five days of age, birds were divided into eight treatments (21 birds each), each treatment contained 3 replicates of 7 birds each. Four levels of dietary ME (recommended (R), R-100, R-200 and R-300 Kcal /Kg diet) and two levels of dietary betaine (0.00 and 0.05%) were used in a 4×2 factorial arrangement giving eight dietary treatments.

Results obtained could be summarized in the following:

Growth performance: Inclusion of betaine in broiler diet at 0.05% caused a significant increase in LBW at 42 days and LBWG during the period from 5 to 42 days. Chicks fed control diet -100 Kcal ME/Kg diet + 0.05% betaine had significantly higher LBW and LBWG during the period from 5 to 42 days of age, while, chicks fed control diet -300 Kcal ME/Kg diet + 0.05% betaine (D8) had lower LBW and LBWG values during the same period (differences between D8 and control diet were not significant). Chicks fed R-300 Kcal/Kg diet had significantly lower FI during the period from 5 to 42 days. Betaine supplementation and interaction due to level of ME x betaine addition insignificantly affected FC during all periods studied. Chicks fed R-100 Kcal/Kg diet had better CPC during the period from 5 to 42 days.

Slaughter parameters%, blood parameters and mortality rate%: Level of ME, betaine supplementation and interaction due to level of ME x betaine addition insignificantly affected slaughter parameters and some blood parameters during all experimental periods. Mortality% was within normal limits and not related to treatments studied.

Economical efficiency (EEf): Economical and relative efficiency (EEf) values during the period from 5 to 42 days of age was improved of chicks fed all experimental diets with or without betaine supplementation as compared with those fed the control diet.

Generally, all experimental treatments improved Ross performance during the period from 5 to 42 days as compared with control diet, thus me be due to betaine supplementation which has beneficial in heat stressed broilers, betaine also has a more pronounced effect when FI and dietary energy are limiting. On the other hand, it can be concluded that ME can be reduced from the recommended level by 300 kcal/kg and supplement these diets with betaine for Ross strain reared during the summer period.

Key words: Triticale, betaine, metabolizable energy, heat stress and broiler performance.

INTRODUCTION

The rapid growth of modern broiler strains, coupled with lower prices, can serve as a partial solution to widespread protein malnutrition in most developing countries in the tropics and offer alternative means of increasing income. However, broiler production in the tropics is faced with major challenges such as high feed costs and heat stress during hot periods of the year. Ambient temperature is the most environmental factor, which affects all physiological processes and productive performance of animal. Heat stress is known to be one of the major problems that usually faces poultry as well as poultry farmers in summer months **(Sabah *et al.*, 2008)** and causes the loss of revenue that ranges into millions of dollars each year **(Mahmoud *et al.*, 2003).** Chickens have no sweat glands, a rapid metabolism, so they are more sensitive to high ambient temperatures**.** A number of studies reported that the suitable temperature for poultry is between 16 and 25°C **(Cerci *et al.,* 2003** and **Sahin *et al.,* 2006)** and relative humidity of 60-70% is ideal for broiler as reported by **Hoffman and Gwin (1954).** Any deviation especially on the higher side depresses both the survival and the production **(Tayeb, 2009** and **Yahav, 2009).** While, according to **Bollengier *et al*. (1998)** heat stress begins when the ambient temperature becomes higher than 27°C and is readily apparent above 30°C**.**

Large economic losses occur because of mortality and decreased production. Acute stress caused by sudden increases in temperature results in large number of death and evokes a wide range of behavioral, biochemical, physiological and molecular adjustments **(Etches *et al*., 1995).** The nature and magnitude of these adjustments depend upon the degree of heat stress imposed. Typical responses include elevations in plasma concentrations of corticosteroids, protein, glucose, sodium and decrease in relative weights of adrenal, bursa, spleen and thyroid **(Abou El-Soud *et al*., 2006).** Also, broilers can adjust to heat stress by physiological mechanisms (such as elevated body temperature, panting and respiratory alkalosis) and also those directed at reducing heat production **(Gray *et al*., 2003).**

As poultry house temperature increases, respiration rates of poultry and body temperature loss increase. This accelerates with the increase of moisture in the poultry house **(Vona *et al.,* 1984).** At the same time, heat stress increases lipid peroxidation as a consequence of increased free radical generation which can have various deleterious effects in poultry such as metabolic disturbances, cell injury and changes in enzyme activity **(Sahin and Kucuk, 2003)**. Heat stress depressed immune function also causes mortality **(Younis, 2007)** in fowls. Thus it has become necessary to avoid heat stress in order to prevent unnecessary suffering and reduced productivity. 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, feeding and housing environment to alleviate the problem (**Linn *et al*., 2006).**

In order to overcome the adverse effect of heat stress on broiler performance, a considerable amount of research has been conducted upon nutritional parameters such as increasing dietary metabolizable energy (ME) to improve broiler performance during heat stress **(Raju *et al*., 2004).** While, **Baghel and Pradhan (1990)** and **Hoffmann *et al*. (1991)** recommended reducing dietary ME during hot conditions. The energy requirement of birds decreases as the ambient temperature increases above 21°C **(Daghir, 1983).** On the other hand, adequate energy intake during the summer month is very important for broiler since any excess energy consumption is deposited primarily as fat in the body (indicating the wastage of dietary energy) and birds obesity is normally associated with lower production and feed efficiency **(Hocking *et al*., 2002)**. Also, obesity in birds increases the incidence of reproductive failure, death due to heart failure and impaired thermoregulation **(Garlich, 1979)**. So, it is necessary to provide adequate energy intake to control body heat and to get good performance.

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).** Betaine added to feed or drinking water has been shown to be beneficial in heat stressed broilers by helping birds to stave off dehydration **(Konca and Kinkpinar, 2008).** During recent years, betaine has gained increasing attention as commercially feed additive in poultry nutrition with the most popular forms anhydrous betaine, betaine monophosphate and betaine hydrochloride. Betaine, the trimethyl derivative of the amino acid glycine ((Me)3-N+-CH2COO−) **(Eklund *et al.,* 2005).** Betaine also acts as a methyl donor, which in turn may be used for the synthesis of methionine, carnitine, phosphatidyl choline and creatine, which play a key role in protein and energy metabolism **(Eklund *et al.*, 2005** and **Ratriyanto *et al.*, 2009).** Furthermore, betaine has many major metabolic functions, it acts as an osmolyte, which reduces the negative effects of dehydration of high temperature or diseases **(Garcia *et al.*, 2000)** and improves immune response as will as productivity **(Remus *et al.*, 2004** and **Wang *et al.*, 2004).** Its ability to protect intestinal microbes against osmotic variations and improves microbial fermentation activity which might improve nutrient digestibility **(Ratriyanto *et al.*, 2009).** Betaine also has a more pronounced effect when FI and dietary energy are limiting **(Wray *et al.*, 2004** and **Dunshea *et al.*, 2009).**

Betaine was effective in improving growth and feed conversion (FC) and has a methionine sparing effect in broilers **(Garcia *et al*. 2000). Hassan *et al*. (2005)** reported that betaine addition at either 0.072 or 0.144% significantly improved LBW by 4.4 and 4.8%, respectively. Also, **Waldenstedt *et al*. (1999)** reported that dietary betaine addition improved performance of chicks. **Saunderson and Mackinlay (1990)** reported that accumulation of betaine in the cell protects it from osmotic stress.

The traditional feed grains, in Egypt, corn and soybeans, are not produced in quantities that make them available to poultry. In Egypt, some nontraditional feed grains prove to be useful whereas others do not. 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 is an alternative cereal grains that is a hybrid of wheat and rye. Triticale 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).** The higher level and greater availability of phosphorus allows for less phosphorus supplementation when using triticale in diet formulation as opposed to maize besides, using such diets reduces feed cost and phosphorus pollution. In several studies with broilers show no differences in productivity, even when diets consist of 100% triticale (**Maurice *et al.*, 1989** and **Emam, 2010**). Also, **Chapman *et al.* (2005)** indicated that the daily LBWG for the diets using triticale was 5% higher than for the corn-based diet.

Tollba *et al.* (2007a) reported that average temperature in Egypt is around 30ºC during 6 months in the year. Under these conditions, heat stress is particularly a great problem when hens are kept in convention naturally ventilated houses, which have proven ineffective in many regions of the country. Dietary manipulations are normally applied to alleviate the negative effects of hot climate on performance of broiler chicks, instead of the high cost of cooling poultry buildings. So, dietary supplementation of some compounds such as amino acid (betaine) may give us the opportunity to take appropriate preventive to avoid the adverse effects of hot summer months on broiler performance. However, information are lacking on the use of betaine at lower levels of ME during the summer season conditions. Therefore, the objective of the present study to determine the effects of betaine supplementation at lower levels of ME (qualitative feed restriction) on performance, mortality rate and some physiological response of broiler strain reared during the summer period.

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**.**

A total numbers of 168 one-day old unsexed Ross broiler chickens were initially fed a control diet for four days. At five days of age, birds were divided into eight treatments (21 birds each), each treatment contained 3 replicates of 7 birds each. Chicks were raised in electrically heated batteries with raised wire mesh floors and had a free access of feed and water. Batteries were placed into a room provided with a continuous light and fans for ventilation. The birds were reared under similar environmental conditions, 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). Feed and water were supplied *ad libitum.* Four levels of dietary ME (recommended (R), R-100, R-200 and R-300 Kcal/Kg diet) and two levels of dietary betaine (0.00 and 0.05%) were used in a 4×2 factorial arrangement giving eight dietary treatments.

The experimental treatments were as follows:

1- Chicks were fed the control diet (D_1).
2- Chicks were fed D_1+ 0.05% betaine (D_2).
3- Chicks were fed D_1 -100 Kcal ME/Kg diet (D_3).
4- Chicks were fed D_1 -100 Kcal ME/Kg diet + 0.05% betaine (D_4).
5- Chicks were fed D_1 -200 Kcal ME/Kg diet (D_5).
6- Chicks were fed D_1 -200 Kcal ME/Kg diet + 0.05% betaine (D_6).
7- Chicks were fed D_1 -300 Kcal ME/Kg diet (D_7).
8- Chicks were fed D_1 -300 Kcal ME/Kg diet + 0.05% betaine (D_8).

The tested raw material was analyzed for moisture, CP, ether extract (EE), CF, ash, NFE% and ME kcal/Kg, by the methods outlined by Association of Official Analytical Chemists, **A.O.A.C. (1990)**. The determined chemical analysis of triticale grains (grown locally) showed that triticale grains contained, 10.20, 12.50, 1.00, 4.06, 1.85, 70.39% and 3000.0 for moisture, CP, EE, CF, ash, NFE% and ME kcal/Kg (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).), respectively. And soy bean meal contained, 10.00, 42.00, 1.90, 4.50, 2.50, 39.10% and 2230.0 for moisture, CP, EE, CF, ash, NFE% and ME kcal/Kg (the ME value was calculated according to **NRC, 1994**), respectively.

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 composition and calculated chemical analyses of the experimental diets are shown in Table 1.

Table 1: Composition and analyses of the experimental diets.

Items	Starter				Grower				Finisher			
	Level of metabolizable energy, 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	58.00	58.00	58.00	58.00	62.00	62.00	62.00	62.00	64.00	64.00	64.00	64.00
Soybean meal	24.68	25.50	26.53	27.37	18.20	21.45	24.52	27.64	19.24	22.40	23.62	24.52
Corn glutein meal	8.53	7.71	6.80	5.94	9.86	7.74	5.76	3.71	5.87	3.82	2.79	1.92
Wheat bran	0.00	1.15	2.20	3.38	0.00	0.00	0.00	0.00	0.00	0.00	0.98	2.09
Calcium carbonate	1.55	1.55	1.55	1.55	1.40	1.40	1.40	1.41	1.35	1.35	1.35	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 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	1.50	1.50	1.48	1.43	1.40	1.38	1.36
Vegetable oil [3]	4.18	3.04	1.91	0.78	5.79	4.77	3.74	2.72	7.17	6.15	5.03	3.90
DL–Methionine	0.26	0.27	0.27	0.28	0.17	0.18	0.19	0.21	0.11	0.12	0.12	0.13
L-Lysine HCl	0.47	0.45	0.42	0.40	0.42	0.36	0.29	0.23	0.23	0.16	0.13	0.11
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	5.44	4.33	3.23	2.13	7.00	5.99	4.97	3.96	8.32	7.31	6.22	5.12
Linoleic acid	2.87	2.23	1.60	0.96	3.78	3.22	2.65	2.09	4.58	4.02	3.39	2.75
Crude fiber	3.72	3.87	4.02	4.17	3.61	3.73	3.84	3.96	3.69	3.81	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	3010.3	2910.1	2810.1	2710.1	3175.1	3075.1	2975.1	2875.1	3225.0	3125.3	3025.0	2925.1
Cost (£.E./ton) [5]	2490.7	2406.7	2315.8	2230.1	2493.0	2391.5	2293.3	2199.1	2374.8	2274.4	2181.7	2096.3
Relative cost [6]	100.0	96.62	92.97	89.54	100.0	95.93	91.99	88.21	100.0	95.77	91.87	88.27

[1] Recommended [2]Each 3.0 Kg of the Vit. and 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.

The vaccination program adopted by recommended requirements according to standard commercial guidelines. 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 feed conversion (FC, g feed/g gain) and live body weight gain (LBWG) were calculated. Crude protein conversion (CPC) and caloric conversion ratio (CCR) were also calculated. 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.

At the end of the finishing period (42 days of age), slaughter tests were performed using three chicks around the average LBW of each treatment. Birds were 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.

In Egypt, during summer season (from June to August 2011), the average minimum and maximum ambient temperatures ranged between 21.75 and 40.65^{0}C, relative humidity 51.39% and temperature-humidity index (THI) from 31.26 to 57.85% under Fayoum Governorate, Egypt (Central Laboratory for Agricultural Climate) as show in Table 2, which indicated that broiler suffered from high environmental temperature (severe heat stress) which caused many troubles. According to **Marai *et al.* (2002)** there is severe heat stress when THI is higher than 28.9.

The THI was calculated according to the formula by **Marai *et al.* (2001)** as follows **:** THI = db°C–[(0.31–0.031RH)×(db°C–14:4)].

Where: db°C is dry bulb temperature in Celsius degrees, and RH is the relative humidity as a percentage

Table 2: Temperature (Cº) and relative humidity% during the experimental period from June to August 2011*.

Items	Temperature (Cº)		Relative humidity%	Temperature humidity index (THI)	
	Minimum	Maximum		Minimum	Maximum
Minimum	19.29	34.06	36	24.44	46.10
Maximum	24.25	44.65	73	41.86	66.63
Mean	21.75	40.65	51.39	31.26	57.85
± Standard error	0.23	0.47	1.58	0.69	0.83

* Central Laboratory for Agricultural Climate and **Fathi (2013)**

To determine the economical efficiency for meat production, the amount of feed consumed during the entire experimental period was obtained and multiplied by the price of one Kg of each experimental diet 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 (**SPSS, 1999**), according to the follow general model:

$$\mathbf{Y_{ijk} = \mu + E_i + B_j + EB_{ij} + e_{ijk}}$$

Where:

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

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

$\mathbf{B_j}$: betaine supplementation effect (**j**: 0.00 and 0.05%)

$\mathbf{EB_{ij}}$: interaction of level of energy effect by betaine supplementation effect

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

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

RESULTS AND DISCUSSION:

Growth performance: Impact of betaine supplementation to triticale diets varying in their ME content on live body weight (LBW) and live body weight gain (LBWG) of broiler reared during summer season are shown in Table 3. Level of ME effect was significant ($P \leq 0.01$) for LBW at 23 and 42 days and LBWG during the periods from 12 to 23 and 5 to 42 days of age (Table 3). Chicks fed recommended level of ME (R) -100 Kcal/Kg diet had higher LBW and LBWG during these periods, while, chicks fed R-300 Kcal /Kg diet had lower LBW and LBWG values during the same periods (differences between R and R-300 were not significant). However, level of ME had insignificant effect on LBW at 5 and 11 days of age and LBWG during the periods from 5 to 11 and 24 to 42 days.

Inclusion of betaine in broiler diet at 0.05% caused a significant increase in LBW ($P \leq 0.05$) at 42 days and LBWG ($P \leq 0.01$ and $P \leq 0.05$) during the periods from 24 to 42 and 5 to 42 days of age. On the other hand, chicks fed diets containing 0.05% betaine had higher LBW and LBWG values during these periods (Table 3).

Interaction due to level of ME x betaine addition (experimental treatments) had significant for LBW at 23 and 42 days and LBWG during the periods from 12 to 23 and 5 to 42 days of age (Table 3). Chicks fed control diet -100 Kcal ME/Kg diet + 0.05% betaine had higher LBW and LBWG during these periods, while, chicks fed control diet -300 Kcal ME/Kg diet + 0.05% betaine (D_8) had lower LBW at 23 and 42 days and LBWG values during the periods from 12 to 23 and 5 to 42 days of age (differences between D_8 and control diet were not significant). However, its had insignificant effect on LBW at 5 and 11 days of age, and LBWG during the periods from 5 and 11 and 24 to 42 days (Table 3).

Table 3: Effect of betaine supplementation to triticale diets varying in their metabolizable energy (ME) content on live body weight (LBW, g) and live body weight gain (LBWG, g) of Ross broiler chicks.

Items		LBW, g (age, days)				LBWG, g (age period, days)			
		5	11	23	42	5-11	12-23	24-42	5-42
Level of ME, Kcal./Kg (L):									
Recommended(R)		114.88	198.39	653.31^{C}	1626.9^{B}	83.51	451.78^{C}	940.2	1510.6^{B}
R-100		114.58	197.50	800.75^{A}	1860.2^{A}	82.92	603.25^{A}	1027.1	1740.6^{A}
R-200		114.94	189.04	726.20^{B}	1724.8^{AB}	76.99	538.32^{B}	978.8	1610.0^{AB}
R-300		114.16	193.07	640.62^{C}	1565.1^{B}	80.62	446.93^{C}	892.7	1448.5^{B}
±SEM[1]		2.22	5.54	18.89	54.55	3.97	17.49	42.76	54.70
Betaine (B)%:									
0.00		114.60	194.50	697.07	1623.0^{b}	80.59	501.19	899.6^{B}	1505.6^{b}
0.05		114.68	194.50	713.37	1765.5^{a}	81.43	518.96	1019.8^{A}	1649.3^{a}
±SEM		1.57	3.92	13.61	38.12	2.84	12.61	29.88	38.22
L × B% (treatments):									
R	**0.00**	114.89	198.93	648.54^{de}	1558.0^{c}	84.04	445.31^{cd}	875.0	1441.7^{c}
	0.05	114.88	197.86	658.08^{de}	1695.8^{bc}	82.98	458.25^{cd}	1005.3	1579.4^{bc}
R-100	**0.00**	115.01	199.57	766.36^{ab}	1721.0^{bc}	84.56	566.79^{ab}	924.4	1599.8^{bc}
	0.05	114.15	195.43	835.14^{a}	1999.4^{a}	81.28	639.71^{a}	1129.8	1881.3^{a}
R-200	**0.00**	114.45	187.36	696.93^{bcd}	1595.0^{c}	75.69	509.57^{bc}	887.9	1481.2^{c}
	0.05	115.42	190.71	755.46^{abc}	1854.5^{ab}	78.28	567.08^{ab}	1069.8	1738.8^{ab}
R-300	**0.00**	114.07	192.14	676.46^{cde}	1618.0^{bc}	78.07	483.08^{cd}	911.0	1499.5^{bc}
	0.05	114.25	194.00	604.79^{e}	1512.1^{c}	83.16	410.79^{d}	874.4	1397.5^{c}
±SEM		3.14	7.83	26.72	79.38	5.62	24.73	58.66	79.60

a, …e, and A,.. C, values in the same column within the same item followed by different superscripts are significantly different (at P≤0.05 for a to e; P≤0.01 for A to C). **[1] Pooled SEM**

Impact of betaine supplementation to triticale diets varying in their ME content on FI and feed conversion (FC) of broiler reared during summer season are presented in Table 4. Concerning the FI values, significant differences were found due to level of ME throughout all the experimental periods studied. Chicks fed recommended level of ME had lower FI during the periods from 5 to 11 and 12 to 23 days and those fed R-300 Kcal/Kg diet had lower FI during the periods from 24 to 42 and 5 to 42 days, while, chicks fed R-300 Kcal/Kg diet had higher FI value during the period from 5 to 11 days and those fed R-100 Kcal ME/Kg diet had higher FI during the other periods studied (Table 4).

As shown in Table 4, betaine supplementation increase FI during all periods studied compared with those fed betaine un-supplement diet (this may be due to improve the palatability of feed **(Kidd *et al.*, 1997)**). On the other hand, betaine supplementation improves LBW and LBWG compared with those fed betaine un-supplemented diet (the improvement noted in LBW and LBWG has been attained due to significant increase in FI). The results of the present findings are in agreement with those of **Nawaz *et al.* (2006)** who reported increased FI with the reduction in dietary ME. In this respect, **Fan *et al.* (2008)** showed that LBWG of ducks increased and FI decreased significantly but FC improved significantly as dietary energy increased from 2.600 to 3.100 kcal of ME/kg. Improvement in FC of ducks appears to be due to the decrease in feed intake caused by high dietary energy. Increasing dietary energy level could improve FC of broilers by reducing FI **(Ghaffari *et al.*, 2007).**

Table 4: Effect of betaine supplementation to triticale diets varying in their metabolizable energy (ME) content on feed intake (FI, g) and feed conversion (FC) of Ross broiler chicks.

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
Level of ME, Kcal./Kg (L):									
Recommended		122.54[C]	921.92[B]	1997.9[B]	3048.8[B]	1.60	2.10[A]	2.21	2.04
R-100		127.82[B]	1027.14[A]	2116.7[A]	3285.7[A]	1.66	1.74[C]	2.17	1.93
R-200		128.21[B]	1018.46[A]	2070.2[AB]	3212.0[A]	1.81	1.93[B]	2.16	2.02
R-300		133.39[A]	933.65[B]	1884.8[C]	2950.0[B]	1.76	2.17[A]	2.16	2.07
± SEM[1]		1.56	8.82	31.15	39.17	0.10	0.06	0.11	0.07
Betaine (B)%:									
0.00		126.40[b]	965.83[b]	1964.6[B]	3057.2[B]	1.70	2.00	2.26	2.06
0.05		129.59[a]	984.75[a]	2070.1[A]	3191.0[A]	1.71	1.97	2.09	1.97
± SEM		1.11	6.30	21.77	27.37	0.07	0.05	0.08	0.04
L × B% (treatments):									
R	**0.00**	120.23	927.61[DE]	2008.5[BC]	3065.2[BC]	1.55	2.16	2.40	2.14
	0.05	124.86	916.23[E]	1987.3[BC]	3032.3[BC]	1.65	2.04	2.02	1.94
R-100	**0.00**	123.71	997.71[B]	2043.3[B]	3171.5[B]	1.58	1.83	2.29	2.03
	0.05	131.93	1056.57[A]	2190.0[A]	3400.0[A]	1.73	1.66	2.04	1.84
R-200	**0.00**	128.07	979.36[BC]	1906.7[BC]	3003.1[BC]	1.83	1.96	2.20	2.06
	0.05	128.36	1057.56[A]	2233.7[A]	3420.9[A]	1.79	1.90	2.12	1.98
R-300	**0.00**	133.57	958.65[CD]	1900.0[C]	2989.2[C]	1.83	2.06	2.14	2.03
	0.05	133.21	908.64[E]	1869.6[C]	2910.9[C]	1.68	2.28	2.18	2.12
±SEM		2.21	12.48	45.33	57.01	0.15	0.09	0.15	0.09

a, …b, and A,.. E, values in the same column within the same item followed by different superscripts are significantly different (at P≤0.05 for a to b; P≤0.01 for A to E).
[1] Pooled SEM

The present improvement in FC ratio by betaine supplementation are in accordance with those of **Hassan *et al.* (2005)** and **Tollba *et al.* (2007b).** These results are in harmony with those obtained by **Nassiri *et al.* (2005)** who reported that betaine supplement improved LBW and FC ratio in starters (0-21 days) and growers (21-42 days). These findings are in agreement with those reported by **Remus (2002)** who demonstrated that positive impact on bird performance of supplementing the diet with betaine. When broiler chicks were subjected to high cycling environmental temperatures, betaine significantly improved FC at 49 days of age. Also, **Abd El-Gawad *et al.* (2005)** concluded that the use of betaine supplemented diets (500, 1000 or 1500 ppm) my be considered as a suitable mean to overcome the depressing effect of heat stress. The dietary betaine level of 1500 ppm would be preferable for chicks kept ay hot conditions, with respect to growth performance and economic efficiency. **Kettunen *et al.* (2001)** studied the role of betaine in the osmoregulation of broiler chick intestinal tissue. They found that the presence of betaine in the hyperosmatic incubation medium in vetro would reduce the water loss from the intestinal tissue. Improved FC may have been attributed to the involvement of betaine in protection of intestinal epithelium against osmotic disturbance. Betaine is indirectly involved in the synthesis of carnitine, which is required for transporting long chain fatty acids across inner mitochondrial membranes for oxidation **(Wang *et al.*, 2004).** The research showed that betaine led to a decrease in hetrofhile/lymphocyte ratio (H/L) and body temperature **(Zulkifli *et al.,* 2004)**. In contrast to these observations there have been other reports demonstrating that betaine had no significant effect on final weight, FI and FC ratio (**Zhan *et al.,* 2006).**

Interaction due to level of ME x betaine addition (experimental treatments) had significant for FI during the periods from 12 to 23, 24 to 42 and 5 to 42 days of age (Table 4). Chicks fed control diet -200 Kcal ME/Kg diet + 0.05% betaine had higher FI during these periods, while, chicks fed control diet -300 Kcal ME/Kg diet + 0.05% betaine (D_8) had lower FI values during the same periods (differences between D_8 and recommended level of ME were not significant). However, its had insignificant effect on FI during the period from 5 and 11 days (Table 4).

Insignificant (P>0.05) effects were observed in FC value except, the period from 12 to 23 days (Table 4). Chicks fed R-300 Kcal/Kg diet had the worst FC value during these period, and those fed R-100 Kcal/Kg diet had the best FC value during the same period.

Betaine supplementation and interaction due to level of ME x betaine addition insignificantly affected FC during all periods studied (Table 4), Numerical improvements in FC were frequently observed when betaine was added and all experimental treatments improved FC (P>0.05) during the period from 5 to 42 days of age as compared with control diet however, these did not reach a level of statistical significance (Table 4). It can be concluded that ME can be reduced from the recommended level by 300 Kcal/Kg diet and supplement these diet with betaine without affecting performance.

There is some evidence that betaine reduces energy expenditure for pumping jons in cells exposed to hyperosmotic media **(Moeckel *et al.,* 2002).** The spared energy may promote cell proliferation **(Eklund *et al.,* 2005).** Therefore, with betaine in the feed, birds are able to retain water allowing more energy for growth **(Jahanian and Rahmani, 2008).**

Impact of betaine supplementation to triticale diets varying in their ME content on crude protein conversion (CPC) and caloric conversion ratio (CCR) of broiler reared during summer season are shown in Table 5.

Level of ME effect was significant for CPC during the periods from 12 to 23 and 5 to 42 days of age and CCR during the period from 12 to 23 days of age (Table 5). It is clear that, chicks fed R-100 Kcal/Kg diet had better CPC and CCR values during the previous periods, while, chicks fed R-300 Kcal/Kg diet had worst CPC values during the periods from 12 to 23 and 5 to 42 days of age (differences between R and R-300 were not significant) and chicks fed recommended level of ME had worst CCR value during the period from 12 to 23 days of age.

Betaine supplementation and interaction due to level of ME x betaine addition insignificantly affected CPC and CCR during all experimental periods (Table 5). Numerical improvements (P>0.05) in CCR were frequently observed when betaine was added, also, all experimental treatments improved CCR (P>0.05) during the period from 5 to 42 days of age as compared with control diet however, these did not reach a level of statistical significance (Table 5). These results agree with those of **Eklund *et al.* (2005)** and **Ratriyanto *et al.* (2009)** who reported that chicks fed diet supplemented with betaine improves energy availability.

Table 5: Effect of betaine supplementation to triticale diets varying in their metabolizable energy (ME) content on crude protein conversion (CPC) and caloric conversion ratio (CCR) of Ross broiler chicks.

Items		CPC (age period, days)				CCR (age period, days)			
		5-11	12-23	24-42	5-42	5-11	12-23	24-42	5-42
Level of ME, Kcal./Kg (L):									
Recommended		0.375	0.462^{A}	0.442	0.405^{ab}	4.81	6.67^{A}	7.12	5.91
R-100		0.389	0.383^{C}	0.433	0.383^{b}	4.82	5.36^{C}	6.77	5.42
R-200		0.425	0.424^{B}	0.432	0.415^{ab}	5.08	5.73^{BC}	6.53	5.63
R-300		0.413	0.478^{A}	0.432	0.431^{a}	4.76	6.25^{AB}	6.32	5.65
± SEM[1]		0.03	0.01	0.02	0.01	0.30	0.19	0.34	0.16
Betaine (B)%:									
0.00		0.399	0.440	0.452	0.413	4.84	6.06	6.96	5.73
0.05		0.403	0.433	0.418	0.404	4.90	5.95	6.42	5.57
± SEM		0.02	0.01	0.02	0.01	0.21	0.13	0.23	0.12
L × B% (treatments):									
R	**0.00**	0.363	0.475	0.479	0.414	4.65	6.85	7.73	6.07
	0.05	0.388	0.450	0.404	0.396	4.96	6.49	6.51	5.75
R-100	**0.00**	0.372	0.402	0.458	0.390	4.61	5.63	7.16	5.53
	0.05	0.406	0.365	0.408	0.377	5.03	5.09	6.38	5.30
R-200	**0.00**	0.429	0.430	0.441	0.418	5.13	5.82	6.66	5.69
	0.05	0.421	0.417	0.423	0.412	5.04	5.64	6.40	5.58
R-300	**0.00**	0.430	0.454	0.428	0.431	4.96	5.93	6.27	5.63
	0.05	0.396	0.502	0.436	0.431	4.56	6.56	6.38	5.67
± SEM		0.04	0.02	0.03	0.02	0.42	0.26	0.48	0.24

a, …b, and A,.. C, values in the same column within the same item followed by different superscripts are significantly different (at P≤0.05 for a to b; P≤0.01 for A to C). [1] Pooled SEM

Slaughter parameters%:

The slaughter parameters of chicks fed different levels of ME with or without betaine supplementation are presented in Table 6. It is clear that, level of ME, betaine supplementation and interaction due to level of ME x betaine addition insignificantly affected slaughter parameters during all experimental periods (Table 6).

Numerical improvements in relative weights of bursa and thymus were frequently observed when betaine was added compared with that of control group, however, these did not reach a level of statistical significance. Therefore, it may be concluded that level of ME used in this study can be used at 5 to 42 days of age without any detrimental effect on slaughter parameters.

Similarly, **Tollba *et al.* (2007b)** reported significant increase was detected in relative weights of thymus and spleen in supplemented treated groups compared with that of control group**,** the increase in weights of thymus and spleen value probably are due to the immunostimulate as affected by feeding of betaine. These results agree with the findings of **Nawaz *et al.* (2006)** who reported that no effect of ME on edible carcass characteristics or abdominal fat weight**.** Also, **Ghaffari *et al.* (2007)** and **Fan *et al.* (2008)** reported that high dietary energy did not affect breast and rear meat (P≤0.05), but abdominal fat increased (P≤0.05) when dietary ME was above 2.700

kcal/kg**,** and this fat was usually considered to be waste product when birds were processed further, which indicated the economic loss for poultry producers.

At high temperature meat yield particularly breast meat yield is reduced (**Yalcin *et al.,* 2001**). **Zaman *et al*. (2008)** observed a small effect of energy dilution on carcass and breast yields, but, abdominal fat and liver weights increased with increasing dietary ME in the diets. **Esteve and Mack (2000)** reported that betaine significantly improved carcass percentage but not carcass and breast weight, breast yield, abdominal fat weight and abdominal fat percentage. **Abd El-Gawad *et al.* (2005)** reported that dietary betaine supplementation had no significant effect on dressing and breast percentages except the chicks fed diets supplemented with 1500 ppm betaine which recorded the highest values ($P \leq 0.05$) of dressing and breast meat percentages as compared with control group (without betaine). Also, they showed that abdominal fat percentage gradually declined significantly ($P \leq 0.05$) as dietary betaine increased.

However, some researchers reported that abdominal fat increased with betaine supplement **(Attia *et al.,* 2005)**. **Waldroup *et al.* (2006)** suggested that additions of betaine in broiler diets (under heat stress) significantly increased carcass dressing percentage at 42 days of age but not at 48 days and may improve breast yield**.**

Blood parameters: As shown in Table (7), level of ME, betaine supplementation and interaction due to level of ME x betaine addition insignificantly affected some blood parameters during all experimental periods (Table 7). Numerically, chicks fed diet supplemented with betaine had higher values of white blood cells count (WBCs), red blood cells count, hemoglobin, hematocrit, mean corpuscular volume and mean corpuscular hemoglobin, while, those fed diet without betaine supplementation had lower values (this me be due to high temperature inhibits antibody production **(Gross, 1992)** but, the difference is not significant during the experimental period. Similar results were observed by **(Tollba *et al.,* 2007b)** who found that supplementing layer diets with betaine for 16 wks increased ($P \leq 0.05$) hemoglobin and hematocrit values when compared with the control diet. **Saunderson and Mackinlay (1990)** reported that accumulation of betaine in the cell protects it from osmotic stress. Increasing the previous blood parameters may indicate that an enhancement of immunity occurred corresponding to feeding betaine as a result of improving FC, absorption and utilization of nutrients **(Tollba *et al.,* 2007b)**.

These effects include the suppression of circulating WBC **(Heller *et al*., 1979)** and increase in the heterophil /lymphocyte ratio (H/L ratio) which is an indicator stress **(Gross and Siegel, 1983).** Also, a positive effect of betaine on immune response **(Remus *et al*., 2004).**

Mortality rate%: Results in Table 8 indicated that the percentage of mortality was 4.75% in chicks fed diet 1, 2 and 3. 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 treatments studied. The aforementioned results are in agreement with those of **Heilbronn and Ravussin** (**2003)** who reported that prolong energy restriction could reduce mortality rate, oxidative stress, visceral fat, energy expenditure**.** In addition to this, **Younis (2007)** found that heat stress causes mortality.

Table 6: Effect of betaine supplementation to triticale diets varying in their metabolizable energy (ME) content on some slaughter parameters% of Ross broiler chicks.

Items		Live body weight (g)	Heart	Liver	Gizzard	Spleen	Total giblets	Abdominal fat	Bursa	Thymus	Breast meat	Rear meat	Carcass weight after evisceration	Dressing
Level of ME, Kcal./Kg (L):														
Recommended(R)		1506.5[b]	0.51	2.62	1.87	0.15	5.15	1.92	0.11	0.44	85.03	84.39	63.58	68.73
-100		1707.5[ab]	0.43	2.39	1.55	0.19	4.56	1.78	0.12	0.33	85.76	83.33	64.02	68.58
-200		1812.0[a]	0.48	2.70	1.42	0.14	4.73	1.69	0.12	0.36	86.51	83.94	64.87	69.60
-300		1562.5[b]	0.47	2.42	1.47	0.17	4.52	1.92	0.18	0.43	85.89	83.47	63.15	67.68
± SEM[1]		71.44	0.03	0.15	0.17	0.02	0.20	0.37	0.02	0.07	0.83	0.97	0.94	0.92
Betaine (B)%:														
0.00		1614.3	0.48	2.56	1.44	0.18	4.66	1.66	0.11	0.36	86.08	83.42	63.99	68.65
0.05		1680.0	0.46	2.50	1.72	0.14	4.82	2.00	0.15	0.41	85.52	84.14	63.82	68.65
± SEM		50.51	0.02	0.10	0.12	0.02	0.14	0.26	0.01	0.05	0.59	0.69	0.66	0.65
L × B% (treatments):														
R	**0.00**	1511.0	0.55	2.64	1.54	0.15	4.87	1.98	0.07	0.37	85.88	83.82	64.54	69.42
	0.05	1502.0	0.47	2.61	2.21	0.15	5.44	1.86	0.15	0.50	84.19	84.96	62.61	68.05
R-100	**0.00**	1650.0	0.43	2.38	1.52	0.19	4.52	1.71	0.11	0.35	84.64	83.38	62.76	67.27
	0.05	1765.0	0.43	2.40	1.58	0.19	4.60	1.86	0.12	0.31	86.89	83.29	65.29	69.89
R-200	**0.00**	1718.5	0.47	2.62	1.30	0.18	4.57	1.23	0.14	0.36	88.06	82.96	65.48	70.05
	0.05	1905.5	0.49	2.78	1.53	0.09	4.90	2.15	0.11	0.36	84.97	84.93	64.26	69.16
R-300	**0.00**	1577.5	0.47	2.62	1.40	0.20	4.69	1.72	0.14	0.38	85.75	83.55	63.16	67.85
	0.05	1547.5	0.46	2.22	1.55	0.13	4.36	2.12	0.22	0.48	86.03	83.39	63.14	67.50
± SEM		101.0	0.05	0.21	0.24	0.03	0.28	0.53	0.03	0.09	1.18	1.38	1.32	1.30

a, …b values in the same column within the same item followed by different superscripts are significantly different (at P≤0.05 for a to b).
[1] Pooled SEM

Table 7: Effect of betaine supplementation to triticale diets varying in their metabolizable energy (ME) content on some blood parameters of Ross broiler chicks.

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) μ^2	Mean corpuscular hemoglobin (MCH) µµg	Mean corpuscular hemoglobin concentration (MCHC)%
Level of ME, Kcal./Kg (L):								
Recommended(R)		13.78	2.39	10.63	34.58	145.00	44.55	30.75
R-100		13.62	2.30	10.45	33.73	146.50	45.40	30.95
R-200		14.30	2.26	10.23	33.25	147.00	45.28	30.78
R-300		15.50	2.37	10.63	34.20	144.25	44.93	31.15
± SEM[1]		0.83	0.13	0.59	1.97	1.53	0.79	0.44
Betaine (B)%:								
0.00		14.26	2.29	10.21	33.04	144.25	44.65	30.96
0.05		14.33	2.37	10.75	34.84	147.13	45.43	30.85
± SEM		0.56	0.09	0.42	1.39	1.08	0.56	0.31
L × B% (treatments):								
R	**0.00**	12.50	2.38	10.75	35.05	147.00	45.15	30.70
	0.05	15.05	2.39	10.50	34.10	143.00	43.95	30.80
R-100	**0.00**	15.25	2.38	10.45	33.80	143.50	44.35	30.90
	0.05	11.98	2.25	10.45	33.65	149.50	46.45	31.00
R-200	**0.00**	14.35	2.22	9.71	31.85	143.50	43.80	30.50
	0.05	14.25	2.30	10.75	34.65	150.50	46.75	31.05
R-300	**0.00**	14.95	2.21	9.95	31.45	143.00	45.30	31.75
	0.05	16.05	2.54	11.30	36.95	145.50	44.55	30.56
± SEM		1.17	0.19	0.84	2.78	2.16	1.11	0.63

[1] **Pooled SEM**

Table 8: The calculated cumulative mortality% of chicks during the period from 5 to 42 days of age.

Items			Total number of chicks at the beginning of experiment	Number of dead birds	Mortality%
Level of ME (Kcal/Kg)	**Betaine%**	**Diet (D)**			
Recommended (R)	**0.00**	**D1**	21	1	4.75
	0.05	**D2**	21	1	4.75
R-100	**0.00**	**D3**	21	1	4.75
	0.05	**D4**	21	0	0
R-200	**0.00**	**D5**	21	0	0
	0.05	**D6**	21	0	0
R-300	**0.00**	**D7**	21	0	0
	0.05	**D8**	21	0	0

Economical efficiency (EEf): Results in Table (9) show that EEf values during the period from 5 to 42 days of age was improved of chicks fed diets 4,7,6,8,5,3 and 2 as compared with those fed the control diet. Chicks fed diet 4 had the best economical and relative efficiency values being 2.085 and 135.51%, respectively followed by chicks fed diet 7 (2.051 and 133.28%, respectively) then chicks fed diet 6 (1.936 and 125.81%, respectively) when compared with chicks fed control diet. Whereas, chicks fed control diet had the lowest corresponding values, being 1.539 and 100.00%, respectively. The relative efficiency varied between 100.00% (diet 1) to 135.51% (diet 4) which is of minor importance relative to other factors of production. On the other hand, results in Table (9) show that EEf values during the period from 5 to 42 days of age was improved of chicks fed all experimental diets with or without betaine supplementation as compared with those fed the control diet. This is logical since heat stress not only causes suffering and death in the birds, but also results in reduced or lost production that adversely affects the profit from the enterprise. This again favors the use of energy restricted with betaine than use of these without betaine supplementation in feeding Ross chicks (Table 9). **Abd El-Gawad *et al.* (2005)** showed that betaine supplementation lowered the feed cost needed to obtain 1 Kg live body weight. The percentage of EEf was improved when betaine was added to broilers feed reared under heat stress. Thus, the economic evaluation provided further evidence for the benefits of using betaine as an attempt to alleviate the influences of heat stress on broiler chicks.

Generally, as mentioned above, broiler suffered from high environmental temperature and humidity (severe heat stress) which caused many troubles (Table 2). The main consequences of hot environment are a reduction in performance, its mainly due to the reduction in FI. But, all experimental treatments improved Ross performance during the period from 5 to 42 days of age as compared with control diet, thus me be due to betaine supplementation which has beneficial in heat stressed broilers, betaine also has a more pronounced effect when FI and dietary energy are limiting. This would not only ensure maximum utilization of ME and every nutrient of the diet but also help to reduce the cost of production and high energy broiler diets resulted in extra deposition of fat indicating the wastage of dietary energy.

On the other hand, it can be concluded that ME can be reduced from the recommended level by 300 kcal/kg and supplement these diets with betaine in hot weather so that heat stress is minimized.

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Table 9: Effect of betaine supplementation to triticale diets varying in their metabolizable energy (ME) content on economical efficiency (EEf) of Ross broiler chicks.

Items	Level of ME, Kcal./Kg							
	Recommended (R)		R-100		R-200		R-300	
	0.00 B*	0.05 B	0.00 B	0.05 B	0.00 B	0.05 B	0.00 B	0.05 B
	D**1	D2	D3	D4	D5	D6	D7	D8
a_1	0.1202	0.1249	0.1237	0.1319	0.1281	0.1284	0.1336	0.1332
b_1	249.07	252.07	240.67	243.67	231.58	234.58	223.01	226.01
a_1 x b_1=c_1	29.946	31.473	29.773	32.147	29.658	30.111	29.787	30.107
a_2	0.9276	0.9162	0.9977	1.0566	0.9794	1.0576	0.9587	0.9086
b_2	249.30	252.30	239.15	242.15	229.33	232.33	219.91	222.91
a_2 x b_2=c_2	231.25	231.16	238.60	255.85	224.60	245.70	210.82	202.54
a_3	2.0085	1.9873	2.0433	2.1900	1.9067	2.2337	1.9000	1.8696
b_3	237.48	240.48	227.44	230.44	218.17	221.17	209.63	212.63
a_3 x b_3=c_3	476.98	477.91	464.73	504.66	415.98	494.03	398.30	397.53
$c_1+c_2+c_3=c_{total}$	738.18	740.54	733.10	792.66	670.24	769.84	638.90	630.18
d	1.4417	1.5794	1.5998	1.8813	1.4812	1.7388	1.4995	1.3975
e	1300.0	1300.0	1300.0	1300.0	1300.0	1300.0	1300.0	1300.0
d x e=f	1874.2	2053.2	2079.7	2445.7	1925.6	2260.4	1949.4	1816.8
f- c_{total} =g	1136.0	1312.7	1346.6	1653.0	1255.3	1490.6	1310.4	1186.6
g/ c_{total}	1.5390	1.7726	1.8369	2.0854	1.8729	1.9362	2.0511	1.8829
r	**100.00**	**115.18**	**119.36**	**135.51**	**121.70**	**125.81**	**133.28**	**122.35**

*** Betaine% ** Diet**

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).

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الملخص العربي

تأثير إضافة البيتايين إلي علائق التريتيكال المختلفة في محتواها من الطاقة الممثلة علي أداء بداري التسمين خلال فصل الصيف

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تم إجراء التجربة في محطة بحوث الدواجن بالعزب بالفيوم – معهد بحوث الإنتاج الحيواني – مركز البحوث الزراعية – وزارة الزراعة بالدقي – مصر . وذلك خلال الفترة من شهر يونيه إلى أغسطس لسنة ٢٠١١. غذيت الكتاكيت عمر يوم ولمدة ٤ أيام علي عليقة المقارنة وتم توزيع ١٦٨ كتكوت غير مجنس (سلالة روس) بصورة عشوائية إلى ثماني معاملات (٢١ طائر/معاملة) كل معاملة مقسمة إلي ثلاثة مكررات (٧ طائر/مكرر). استخدم أربع مستويات من الطاقة الممثلة (المستوي الموصي به (ص))، ص-١٠٠ ، ص-٢٠٠، ص-٣٠٠ كيلو كالورى/كيلو جرام عليقة) ومستويين من البيتايين (صفر و ٠,٠٥%) في تجربة عامليه ٢ x ٤ للحصول علي ٨ معاملات غذائية.
وتم تلخيص النتائج المتحصل عليها كما يلي :

أداء النمو: أدي إضافة البيتايين إلي علائق بداري التسمين إلي زيادة معنويه في وزن الجسم علي عمر ٤٢ يوم ووزن الجسم المكتسب خلال الفترة من ٥–٤٢ يوم. كانت الكتاكيت المغذاه علي عليقة المقارنة ناقص ١٠٠ كيلو كالورى طاقة ممثلة/كيلو جرام عليقة مضاف إليها ٠,٠٥% بيتايين الأعلى معنويا في وزن الجسم ووزن الجسم المكتسب خلال الفترة من ٥–٤٢ يوم، بينما الكتاكيت المغذاه علي عليقة المقارنة ناقص ٣٠٠ كيلو كالورى طاقة ممثلة/كيلو جرام عليقة مضاف إليها ٠,٠٥% بيتايين (عليقة ٨) الأقل معنويا في وزن الجسم ووزن الجسم المكتسب خلال الفترة من ٥–٤٢ يوم (الاختلافات بين عليقة ٨ وعليقة الكنترول غير معنوية). كانت الكتاكيت المغذاه علي عليقة المقارنة ناقص ٣٠٠ كيلو كالورى طاقة ممثلة/كيلو جرام عليقة الأقل معنويا في كمية الغذاء المستهلكة خلال الفترة من ٥–٤٢ يوم. لم يؤثر إضافة البيتايين ولا التداخل بين مستوي الطاقة والبيتايين علي كفاءة تحويل الغذاء الفترات الكلية المدروسة. كانت الكتاكيت المغذاه علي عليقة المقارنة ناقص ١٠٠ كيلو كالورى طاقة ممثلة/كيلو جرام عليقة أحسن كفاءة تحويل للبروتين خلال الفترة من ٥–٤٢ يوم.

قياسات الذبيحة% وقياسات الدم ومعدل النفوق%: لم يؤثر معنوياً مستوي الطاقة والبيتايين ولا التداخل بين مستوي الطاقة والبيتايين علي قياسات الذبيحة% وقياسات الدم. كان معدل النفوق% في المستوي الطبيعي ولم يتأثر بالمعاملات التجريبية.

الكفاءة الاقتصادية: تحسنت قيمة الكفاءة الاقتصادية والنسبية للكتاكيت المغذاه علي كل المعاملات التجريبية سواء المضاف أو غير المضاف إليها البيتايين خلال الفترة من ٥–٤٢ يوم بمقارنتها بالمغذاه علي عليقة المقارنة.

عموماً: تحسن أداء كتاكيت الروس المغذاه علي كل المعاملات التجريبية خلال الفترة من ٥–٤٢ يوم بمقارنتها بالمغذاه علي عليقة المقارنة، ربما يرجع ذلك لإضافة البيتايين والذي له تأثير مفيد أيضاً عند تعرض بداري التسمين للإجهاد الحراري، وللبيتايين تأثير واضح عند تحديد الغذاء والطاقة. وبمعني أخر يمكن التوصية بخفض الطاقة عن المستوي الموص به بمعدل 300 كيلو كالورى/كيلو جرام عليقة مع إضافة البيتايين لسلالة الروس المرباه خلال فترة الصيف.