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DEITARY SUPPLEMENTATION OF BETAINE AS AN ATTEMPT TO ALLEVIATE THE EFFECTS OF HEAT STRESS ON BROILER CHICKS.

Abd El-Gawad, A.H.[1]; M.M.A. El-Moniary[1] and A.A. Hemid[2]

(1) Animal Production Dep. National Research Center, Dokki, Cairo, Egypt.

(2) Poultry Production Dep. Faculty of Agriculture, Ain Shams University , Cairo. Egypt.

ABSTRACT

An experiment was conducted to study the effects of adding graded levels of betaine either alone or in combination with either enzymes preparation (EP) containing ∝-amylase, xylanase and protease or Ascorbic acid (Vitamin C) on productive performance and carcass characteristics of broiler chicks raised under high ambient temperatures. A number of 144 day– old "Hubbard" broiler chicks were assigned to 6 treatment groups of 24 chicks in individual cages where every chick represented one replicate. The six experimental diets were: control treatment diet (T_1) which was formulated to be without supplemental betaine, treatments diets (T_2) , (T_3) and (T_4) which were similar to control diet (T_1) but they were supplemented with commercial betaine (91%) at inclusion rate of 500,1000 or 1500 ppm , respectively. While, (T_5) and (T_6) diets were supplemented with 1000 ppm betaine (91%) combined with 1 kg of EP/Ton or 200 ppm Vitamin C (1 kg 20% / Ton).

Chicks of all treatments had similar growth performance at the end of starter period (18 days of age). Thenafter, body weight of chicks at the end of growing period (40 days of age) increased by increasing dietary betaine level (T_2, T_3, T_4, T_5, and T_6), with priority for T_5 and T_6 ($P<0.05$) over the control (T_1). While, the dietary treatments did not show any significant effect on feed consumption and feed conversion ratio at this age. At 49 days of age, the best results in regard to the productive performance, carcass characteristics and economic efficiency were recorded by using either 1500 ppm added betaine only (T_4) or 1000 ppm betaine combined with EP or Vitamin C (T_5 or T_6, respectively).

It could be concluded that the use of betaine supplemented diets (graded levels alone or in combination with either EP or Vit.C) may be considered as a suitable mean to overcome the depressing effect of heat stress. The dietary betaine level of 1500 ppm or 1000 ppm combined with either 1 kg of EP /Ton feed or 200 ppm Vit.C would be preferable for chicks kept at hot conditions, with respect to growth performance and economic efficiency.

INTRODUCTION

Many studies have been conducted demonstrating the adverse effects of high environmental temperatures on broiler chicks. The use of standard broiler stocks under condition of high ambient temperature reduced growth performance as results of decrease feed intake (EL-Moniary, 1991; El-Moniary *et al.*, 1993, Yalcin *et al.*, 1997, May *et al.*, 1998 and EL-Deeb and Abou-Elmagd, 2001). Birds become heat stressed when they have difficulty in achieving the balance between body heat loss and body heat production. In an effort to maintain body temperature, birds first rely on losing heat from blood vessels near the surface of the skin. As the ambient temperature increased beyond the bird's thermoneutral zone, the bird becomes depend on panting as the mechanism for controlling body temperature. Panting is an effective but energy – expensive way for the bird to control body temperature. While, birds do compensate for water losses associated with panting by consuming more water, its retention in the body cells is limited by the simultaneous loss of electrolytes such as potassium in the urine (Belay *et al.*,1992). Heat stress in birds leads to many biochemical and physiological changes in body such as shift in acid-base balance, hyperthermia, increased demand of O_2 and production of Co_2 , increased production of free radical and corticosterone (Mebta and Sbingari, 1999; and El-Deeb and Abou-Elmagd, 2001).

In order to overcome the adverse effect of heat stress, a considerable amount of research has been conducted depending upon nutritional conditions such as using fat supplementation (Abd EL-Gawad *et al.*, 1993, El-Moniary *et al.*, 1994a and EL-Moniary, 1996), critical essential amino acids (EL-Moniary *et al.*, 1994b), minerals and vitamins (Moreng, 1980), feed additives and growth promoters (Teeter, 1995), electrolytes (Ghazalah *et al.*, 1998), nutrient concentration (El-Moniary, 1996 and Abd El-Gawad *et al.*, 1996) and feeding pelleted diets (Abd EL-Gawad *et al.*, 1993 and 1996). More recently, betaine addition to the feed or drinking water has also been shown to be beneficial in heat stressed broilers. Betaine is a naturally occurring substance found in a wide variety of plant and animal species. It functions in the bird's metabolism as a methyl group donor for the synthesis of many important compounds (Kidd *et al.*, 1997). Also, betaine acts as an intestinal osmolyte and affects the movement of water across the duodenal and ileal epithelium. Thus, dietary betaine supplementation for the chicks would improve the ability of their intestinal tissue to resist water loss in hyperosmotic medium (Kettunen *et al.*, 2001). Currently, literature concerning the effect of supplemental betaine on broiler chicks under heat stress condition is limited.

The normal functions of tissues are dependent upon the stability of the total osmolarity of intracellular and extracellular fluids (Etches *et al.*, 1995). Osmoregulation is the ability of a cell to maintain its structure and function by regulating movement of water in and out of the cell (Kidd *et al.*, 1997). Most cells (animal and plant) adapt to external osmotic pressure or stress by altering the intracellular concentration of low molecular weight organic solutes and inorganic ions (Wunz and Wright, 1993). Animal with high blood osmolarity use organic compounds to regulate approximately 60-70% of their intracellular fluid osmolarity. This is because organic osmolytes (especially betaine) are highly compatible with enzyme function and altering their intracellular concentration does not upset metabolism (Yancey *et al.*, 1982 and Dragolovich, 1994).

Vitamin C (Ascorbic acid) is another compound that the researches worked on to alleviate the effect of heat stress. There are numerous inconsistent and conflicting findings surrounding the effect of Vit.C on broiler performance under heat stress. Some researchers concluded that Vit.C has a positive effect (Pardue *et al.*, 1984; Kafri and Cherry, 1984; Njoku, 1986 and

Al-Homidan, 2000), while others (Stillborn *et al.*, 1988 and Hussein, 1996) reported that vit.C had little or no beneficial effect on broiler performance of chicks maintained under heat stress.

Feed enzymes are increasingly seen as "environ mentally responsible" alternatives to some hormone growth promoters and antibiotics. Sheppy (2001) reported that using enzymes in poultry feed increase the availability of starch, proteins and minerals that are enclosed within the fiber-rich cell walls. The beneficial effects of some enzymes for improving the nutrients availability and bird's performance are well established by Bedford and Morgan (1996). They reported that the addition of commercial enzymes preparations (EP) containing xylanase, B-glucanase and side enzymatic activities improved the feed efficiency of maize/ soybean meal diets for poultry. Greenwood *et al.* (2002) reported that supplementing a corn-soybean meal broiler diets with enzyme preparation containing a mixture of protease, amylase and xylanase resulted in improved body weight.

Therefore , the present experiment was carried out to study the effects of adding graded levels of betaine either alone or in combination with either Vit.C or enzymes preparation (EP) on productive performance and carcass characteristics of broiler chicks raised under high ambient temperatures.

MATERIALS AND METHODS

This experiment was carried out at the Poultry Research Farm, Poultry Production Dept., Fac. of Agriculture, Ain-Shams Univ., Cairo, Egypt, under hot climates of summer season in Egypt; where the maximum environmental temperature ranged from 32-42°C during the experimental period. The experiment comprised 144 one-day-old "Hubbard" broiler chicks which were randomly assigned to 6 different treatments in individual battery cages (replicates) with 24 birds per treatment each in such a way that the groups were equalized as to initial weight (41-42g). Feed and water were offered *ad-libitum* and artificial light was provided 24 hours daily allover the experimental period, which lasted for 7 weeks. Chicks of all treatment groups were kept under similar hygienic and environmental conditions and vaccinated against common diseases.

The different experimental diets (starter, grower and finisher) were formulated according to recommended requirements of "Hubbard" strain used. The birds of control treatment (T_1) were fed corn-soy diet which was formulated without supplemental betaine. The birds of treatments (T_2) , (T_3) and (T_4) were fed diets similar to control diet (T_1) except that they were supplemented with commercial betaine (91%) at inclusion rate of 500, 1000 or 1500 ppm, respectively. However, (T_5) and (T_6) were fed diets similar to control diet (T_1) and supplemented with 1000 ppm betaine (91%) combined with either 1 kg / Ton diet of commercial enzymes preparation containing α-amylase, xylanase and protease or 200 ppm Vitamin C (1Kg 20% /Ton diet). The experimental diets and their calculated analysis are shown in Tables (1), (2) and (3).

Data on body weight, feed intake and calculated feed conversion ratio were recorded at the end of each period, while performance index (PI) was calculated according to North (1981) as follows:

PI = (Live body weight (kg) / feed conversion) x 100.

At seven weeks of age, all the birds were starved for 12 hours then individually weighed prior to slaughter. Five birds from each treatment were taken around the average live weight of the treatment for slaughter test and values were calculated as percentage of live body weight. Each bird was wet plucked, head and legs were removed and the carcass was eviscerated. The carcass with neck, abdominal fat and breast meat yield were separately weighed and expressed as percentage of live body weight.

Data were statistically analyzed using the linear model (SX, 1992). A simple one – way classification analysis followed by least significant difference test (LSD) were used for testing the significance between means.

Table (1): The composition of the experimental starter diets (0 - 18 days of age).

Ingredients	Treatments					
	1	2	3	4	5	6
Yellow corn	570.00	569.50	569.00	568.50	568.00	568.00
Soybean meal (44%)	293.00	→				
Corn gluten meal	80.15	→				
Soybean Oil	14.80	→				
Di-Ca.phosphate	20.00	→				
Limestone	11.00	→				
DL.methionine	1.00	→				
L.Lysine HCl	2.50	→				
NaCl	4.13	→				
Vit. & Min. mix.*	3.42	→				
Betaine (91%)	-	0.50	1.00	1.50	1.00	1.00
Enzyme preparation	-	-	-	-	1.00	-
Vitamin C (20%)	-	-	-	-	-	1.00
Total	1000	1000	1000	1000	1000	1000
Calculated analysis:						
Crude protein %	23.00	→				
ME (k.cal. / kg diet)	3000	→				
Calcium %	1.00	→				
Av. phosphorous %	0.50	→				
Methionine %	0.52	→				
Met. + Cys. %	0.92	→				
Lysine %	1.20	→				
Na %	0.18	→				

*** Vitamin & Mineral mixture supplied per Kg of diet: Vit A, 12000 I.U; Vit D_3, 3100 I.U; Vit E, 30 mg; Vit K_3, 1.65 mg; Vit B_1, 4.4mg; Vit B_2 , 5.5mg; Vit B_6 , 3.3mg; Vit B_{12} , 15µg; Niacin, 53 mg; Pantothenic acid, 11 mg; Folic acid, 1 mg; Biotin, 200µg;Betaine(91%) 420 mg; Copper, 9 mg; Iodine, 1.1mg; Iron, 88 mg; Manganese, 66 mg; Zinc, 40 mg, Cobalt, 0.2mg and Selenium, 0.3 mg.**

**** Calculated based on feed composition Tables of NRC (1994)**

Table (2):The composition of the experimental diets grower diets (19 – 40 days of age) .

Ingredients	Treatments					
	1	2	3	4	5	6
Yellow corn	611.00	610.50	610.00	609.50	609.00	609.00
Soybean meal (44%)	270.00	→				
Corn gluten meal	48.00	→				
Soybean Oil	29.70	→				
Di-Ca.phosphate	18.05	→				
Limestone	12.00	→				
DL.methionine	1.60	→				
L.Lysine HCl	2.08	→				
NaCl	4.15	→				
Vit. & Min. mix.*	3.42	→				
Betaine (91%)	-	0.50	1.00	1.50	1.00	1.00
Enzymes Preparation	-	-	-	-	1.00	-
Vitamin C (20%)	-	-	-	-	-	1.00
Total	1000	1000	1000	1000	1000	1000
Chemical composition:						
Crude protein %	20.30	→				
ME (k.cal. / kg diet)	3100	→				
Calcium %	0.98	→				
Av. phosphorous %	0.46	→				
Methionine %	0.51	→				
Met. + Cys. %	0.87	→				
Lysine %	1.10	→				
Na %	0.18	→				

*** Vitamin & Mineral mixture supplied per Kg of diet: Vit A, 12000 I.U; Vit D_3, 3100 I.U; Vit E, 30 mg; Vit K_3, 1.65 mg; Vit B_1, 4.4mg; Vit B_2 , 5.5mg; Vit B_6 , 3.3mg; Vit B_{12} , 15µg; Niacin, 53 mg; Pantothenic acid, 11 mg; Folic acid, 1 mg; Biotin, 200µg;Betaine (91%) 420 mg; Copper, 9 mg; Iodine, 1.1mg; Iron, 88 mg; Manganese, 66 mg; Zinc, 40 mg, Cobalt, 0.2mg and Selenium, 0.3 mg.**

**** Calculated based on feed composition Tables of NRC (1994)**

RESULTS AND DISCUSSION

Table (4) shows the productive performance of broiler chicks fed the different dietary treatments demonstrated as live body weight, body weight gain, feed consumption, feed conversion ratio, performance index. It appeared from Table (4) that chicks of all treatments had similar growth performance until the end of the starting period (18 days of age), then body weight of chicks at the end of growing period (40 days of age) increased by increasing dietary betaine level either alone (T_2, T_3 and T_4) or combined with either EP (T_5) or Vit.C (T_6). Statistical analysis showed that T_5 and T_6 significantly ($P<0.05$) improved the live body weight over the control (T_1), while the difference between T_2 , T_3 and T_4 and control (T_1) were not significant ($P>0.05$). Also, no significant differences were detected among dietary treatments T_2, T_3, T_4, T_5 and T_6 revealing equal effects for dietary betaine levels of 500, 1000 and 1500 ppm on live body weight. It seems that the effect of using betaine, Vit.C and EP started after the end of starting period. This effect could be a result of environmental temperature (30°C and above) which exceeds the brooding temperature requirement (24°C) during the growing period. Consequently T_2, T_3, T_4, T_5 and T_6 responded positively to the diets containing betaine.

Table (3):The composition of the experimental finisher diets (41 days of age - slaughtering)

Ingredients	Treatments 1	2	3	4	5	6
Yellow corn	612.00	611.50	611.00	610.50	610.00	610.00
Soybean meal (44%)	288.00	→				
Corn gluten meal	10.00	→				
Soybean Oil	53.00	→				
Di-Ca.phosphate	16.00	→				
L.Lysine HCl	0.15	→				
Limestone	12.00	→				
DL.methionine	1.65	→				
NaCl	3.78	→				
Vit. & Min. mix.*	3.42	→				
Betaine (91%)	-	0.50	1.00	1.50	1.00	1.00
Enzymes Preparation	-	-	-	-	1.00	-
Vitamin C (20%)	-	-	-	-	-	1.00
Total	1000	1000	1000	1000	1000	1000
Chemical composition:**						
Crude protein %	18.60	→				
ME (k.cal. / kg diet)	3200	→				
Calcium %	0.94	→				
Av. phosphorous %	0.42	→				
Methionine %	0.47	→				
Met. + Cys. %	0.80	→				
Lysine %	0.96	→				
Na %	0.16	→				

Vitamin & Mineral mixture supplied per Kg of diet: Vit A, 12000 I.U; Vit D_3, 3100 I.U; Vit E, 30 mg; Vit K_3, 1.65 mg; Vit B_1, 4.4mg; Vit B_2 , 5.5mg; Vit B_6 , 3.3mg; Vit B_{12} , 15µg; Niacin, 53 mg; Pantothenic acid, 11 mg; Folic acid, 1 mg; Biotin, 200µg;Betaine(91%) 420 mg; Copper, 9 mg; Iodine, 1.1mg; Iron, 88 mg; Manganese, 66 mg; Zinc, 40 mg, Cobalt, 0.2mg and Selenium, 0.3 mg.

**** Calculated based on feed composition Tables of NRC (1994)**

It is clear from Table (4) that the dietary treatments did not show any significant effect on feed consumption and feed conversion ratio at the end of growing period. These results indicated that the influence of treatments on body weight is independent from feed intake.

Regarding the results of growth performance (Table 4) at the end of experimental period (49 days of age) revealed that body weight of chicks was improved in a step-wise trend by increasing the dietary betaine level. The values of improvement in body weight over the control (T_1) were 126g (6.14%), 156g (7.60%), 244g (11.89%), 262g (12.76%) and 310g (14.66%) for T_2, T_3, T_4, T_5 and T_6, respectively. The analysis of variance indicated that T_4, T_5 and T_6 showed significant ($P<0.05$) increase in body weight when compared to control (T_1), while the difference among betaine treatments (T_2, T_3, T_4, T_5 and T_6) were not significant ($P>0.05$). Also, there were no significant differences between control (T_1) and (T_2) or (T_3) that containing 500 or 1000 ppm of added betaine, respectively. These results showed that, increasing the dietary added betaine level to 500 ppm (T_2) or 1000 ppm (T_3) exerted insignificant effect on live body weight. When the dietary betaine level was increased from 1000 ppm (T_3) to 1500 ppm (T_4) the improvement in body weight become more pronounced ($P<0.05$).

Table (4): Effect of experimental treatments on performance and carcass charateretics of broiler chicks.

ITEM	Treatments 1 (Control)	2 (0.5 kg Beta.)	3 (1 kg Beta.)	4 (1.5 kg Beta.)	5 (Beta. + EP)	6 (Beta. + Vit.C)	SEM*
I W (g/bird)	41	41	42	42	42	41	0.87
at the 18th day of age :							
LBW (g/bird)	497	499	497	496	495	507	16.69
BWG (g/ bird)	456	458	455	454	453	466	16.54
FI (g/bird)	662	655	659	657	641	652	21.28
FCR	1.452	1.430	1.448	1.447	1.415	1.399	0.04
at the 40th day of age :							
LBW (g/bird)	1656^{b}	1742^{ab}	1732^{ab}	1765^{ab}	1814^{a}	1841^{a}	54.93
BWG (g/ bird)	1615^{c}	1701^{abc}	1690^{bc}	1723^{abc}	1772^{ab}	1800^{a}	54.71
FI (g/bird)	3029	3120	3085	3102	3199	3171	79.40
FCR	1.876^{a}	1.834^{ab}	1.825^{ab}	1.800^{ab}	1.805^{ab}	1.762^{b}	0.04
at the 49th day of age :							
LBW (g/bird)	2053^{b}	2179^{ab}	2209^{ab}	2297^{a}	2315^{a}	2354^{a}	67.92
BWG (g/ bird)	2012^{d}	2138^{cd}	2167^{bc}	2255^{abc}	2273^{ab}	2313^{a}	67.74
FI (g/bird)	4084^{b}	4247^{ab}	4252^{ab}	4299^{ab}	4316^{ab}	4385^{a}	106.11
FCR	2.030^{a}	1.986^{ab}	1.962^{abc}	1.906^{bc}	1.899^{c}	1.896^{c}	0.04
PI	101.13^{d}	109.72^{cd}	112.59^{bc}	120.51^{ab}	121.91^{ab}	124.16^{a}	5.41
Dressing (%)	77.05^{b}	77.83^{ab}	77.74^{ab}	78.65^{a}	77.88^{ab}	77.94^{ab}	0.72
Breast (%)	15.34^{b}	16.06^{ab}	16.90^{ab}	17.34^{a}	16.20^{ab}	16.90^{ab}	0.75
AF (%)	2.95^{a}	2.45^{b}	2.32^{b}	2.03^{b}	2.14^{b}	2.29^{b}	0.21

a, b ... means with different superscript(s)in the same row are significantly different ($P < 0.05$).
*** Standard errorr mean for comparison.**
IW = Initial weight, LBW= live body weight, BWG = body weight gain, FI= Feed intake, FCR = feed conversion ratio, PI= Performance Index, AF = abdominal fat

The total values of feed consumption of the experimental treatments (Table 4) revealed that the lowest feed intake was recorded for the control group (T_1), while T_6 which fed diets supplemented with 1000 ppm betaine and 200 ppm Vit.C/kg diet recorded the highest ($P<0.05$) value of feed intake. The other treatments (T_2, T_3, T_4, and T_5) recorded nearly similar values but higher than that of the control group (T_1) . No significant differences ($P>0.05$) were appeared among treatments which received diets supplemented with betaine either alone or combined with either EP or Vit.C (T_2, T_3, T_4, T_5 and T_6). The values of feed conversion ratio at the end of the experiment (Table 4) exhibited a similar trend as that which was observed for the live body weight. Increasing the level of supplemental betaine up to 1000 ppm (T_2 and T_3) resulted in improvement ($P>0.05$) in feed conversion ratio as compared with the control (T_1). However, treatments supplemented with 1000 ppm betaine and EP (T_5) or Vit.C, (T_6) utilized the minimum amount of feed to grow and recorded the best ($P<0.05$) feed conversion ratio. Also, no significant differences were detected among the betaine treatments (T_2, T_3, T_4, T_5 and T_6). These results revealed that the best results in regard to the productive performance of chicks were recorded by using either 1500ppm added betaine only or 1000 ppm betaine combined with EP or Vit.C. This observation may be attributed to the associative dynamic action upon the addition of betaine to either EP or Vit.C. It appeared from this study, also, that the use of betaine supplementation diets (T_2, T_3, T_4, T_5 and T_6) for feeding chicks reared under environmental heat stress conditions increased performance index compared to control (T_1).

These findings are in agreement with those reported by Remus (2002) who demonstrated the positive impact on bird performance of supplementing the diet with betaine. The author reported that, when broiler chicks were subjected to high cycling environmental temperatures, betaine significantly improved feed conversion by 6.3% at 49 days of age. He concluded that, to increase the bird's tolerance to high temperatures, betaine can be a useful tool as part of an overall strategy to minimize the damaging effects of heat stress by maintaining poultry performance. Also, Teeter *et al.* (1999) found that betaine can be used in poultry nutrition to alleviate the growth depression caused by high ambient temperature. Wang (2000) showed that average daily gain increased linearly and feed: gain ratio improved linearly with increasing betaine levels in duck diets (0,500, 1000, 1500 and 2000 ppm).

When environmental temperature is higher than the thermoneutral zone, birds increase panting up to 10 times, (Nilipour, 2000). This usually leads to an excessive loss of carbon dioxide, resulting in raised blood plasma bicarbonate levels and increased blood pH (Linsley and Burger, 1964). The bird attempts to correct blood pH by excreting bicarbonates via the urine. Bicarbonates are negatively charged ions that must be coupled with positively charged ions, such as potassium, to be excreted in urine. However, as potassium is important in maintaining intracellular water balance, a loss of potassium ions via the urine reduces the birds ability to maintain this water balance. The bird employs ion pumps (ionic homeostasis) as compensatory mechanism to control movement of water into and out of the cell, but their use has a high energy cost, with more energy diverted from growth and production to be used for maintenance purposes (Remus 2002). Betaine acts as an osmolyte, helping maintain the bird's cellular water balance to protect cells and tissues from dehydration and osmotic inactivation by facilitating water retention in the body and also help to maintain both the bird's energy balance and feed intake. The osmolyte function of betaine reduces the body cell's reliance on energy – costly ion pumps for maintaining their water balance. The bird's maintenance energy requirement is then reduced, despite osmotic stress, and more energy is available for growth and production (Remus, 2002). 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 hyperosmotic incubation medium *in vitro* would reduce the water loss from the intestinal tissue. Teeter *et al.* (1999) reported that dietary betaine supplementation has shown positive effects on the water balance of broiler chicks stressed by high ambient temperature. Recently, Zulkifli *et al.* (2004) showed that betaine applied in feed or drinking water improved feed efficiency by 3.5% in birds exposed to temperatures up to 35°C. However, the possible influence of betaine on osmotic regulation (acid / base balance), and thereby on the energy metabolism of chicks, requires further research.

It is interested to note that the improvement of feed utilization as a result of adding enzyme preparation reflected on improved feed conversion ratio comparing with control. The results of Zanella *et al.* (1999) confirmed such finding. They concluded that supplementation of the diets with EP containing amylase, protease and xylanase improved broiler performance. The improvement in body weight and feed conversion ratio obtained upon feeding the EP may be attributed to the presence of amylase and non-starch polysaccharides degrading enzymes in EP rather than protease that making the nutrients more available to the bird and improve chick growth performance. Therefore, supplementation of poultry feeds with enzymes in order to increase the efficiency of digestion can be seen as an extension of animal's own digestive process (Sheppy, 2001). This improvement in digestibility, in turn, would improve the energy efficiency of digestion, leaving more energy available for growth. Lyons and Jacques (1987) and El-Gendi *et al.*(2000) suggested, also, that effectiveness of enzyme supplementation to the basal diet may by attributed to its effect in increasing the dietary energy bioavailability.

On the other hand, Njoku (1986) observed an improvement in growth performance of broiler chicks reared in the tropical environment, when their diet was supplemented with 200 ppm Vit.C/kg diet. Also, Pardue *et al.* (1984), Kafri and Cherry (1984), Mebta and Sbingari (1999) and Al-Homidan (2000) found that the inclusions of Vit.C either in the diet or drinking water has beneficial effects on the performance of broiler exposed to heat stress. The present results showed similar effects, when Vit.C was supplemented at level of 200ppm /kg diet. The improvement in growth performance by adding Vit.C may be attributed either to the partial correction in acid-base balance (Mebta and Sbingari, 1999) or to the increase in water intake, which act as a heat sink (Abd-El Samee, 1998).

The effect of different treatments on carcass characteristics (as percentages of live body weight) is shown in Table (4). The results obtained do not show significant effect for the betaine dietary treatments (T_2, T_3, T_4, T_5, and T_6) on dressing and breast percentages except the chicks fed diets supplemented with 1500 ppm betaine (T_4) which recorded the highest values ($P<0.05$) of dressing percentage and breast meat percentage as compared with control (T_1). However, results indicated that abdominal fat percentage gradually declined significantly ($P<0.05$) as dietary betaine increased. It must be mentioned that the control (T_1) recorded higher value of relative weight of abdominal fat than the other treatments (T_2, T_3, T_4, T_5 and T_6). These results are in agreement with those of Remus (2001) who observed 2% or 3% average improvement in breast meat yield in broilers or turkey, respectively fed diets supplemented with betaine during heat stress. The auther reported that the effects of betaine supplementation include better absorption of protein, lysine and methionine in stressed birds as well as the formation of methionine from amino acid homocystine in the liver. Plasma homocystine level decreases in birds fed an adequate diet supplemented with betaine; this would be expected if betaine is being used as a methyl group source by the liver to convert homocysteine into methionine. Thus, betaine may affect the blood amino acid profile through its osmolyte activity in helping alleviate dehydrating stresses in the intestine as well as through its methyl donor role. Specifically, low levels of betaine can be detected in the muscle when broilers have been supplemented at a level of 1000 ppm which associated with breast yield improvement. This suggests that part of the yield response may by relate to the muscle itself. Given the known effect osmolytes on improving growth functions of the cell, it is possible that a portion of yield effect may be related to a more growth related mode in the muscle cell. Also, Wang (2000) studied the effect of betaine on growth and carcass characteristics of meat ducks. He found that betaine supplementation (500 -2000 ppm) significantly increased average daily gain and the feed: gain ratio improved linearly with increasing betaine levels. Analysis of carcass traits indicated that betaine could increase the percentage of breast muscle (P<0.05) and decrease the percentage of abdominal fat (P<0.05) compared with the control treatment. It is concluded that betaine could stimulate beta-oxidation of long chain fatty acids in the inner mitochondria membrane of muscle cells. Ryu *et al.* (2002) reported that betaine functions as an osmoregulator in cells, and its inclusion in the diet can reduce carcass fat of chicks.

The total cost of feed consumption and the total income as well as economic efficiency values of the product for different experimental treatments are shown in Table (5).

Table (5): Effect of experimental treatments on the economic efficiency (EE) of meat production.

ITEMS	Treatments					
	1 (Control)	2 (0.5 kg Beta.)	3 (1 kg Beta.)	4 (1.5 kg Beta.)	5 (Beta. + EP)	6 (Beta. + Vit.C)
Average feed intake (g/bird):						
Starter	662	655	659	657	641	652
Grower	2367	2465	2426	2445	2558	2519
Finisher	1055	1127	1167	1197	1117	1214
Feed price (L.E/kg):						
Starter	1.450	1.463	1.478	1.492	1.516	1.500
Grower	1.416	1.430	1.454	1.460	1.484	1.469
Finisher	1.400	1.415	1.429	1.444	1.468	1.451
Feed cost / bird (L.E)						
Starter	0.960	0.958	0.974	0.980	0.972	0.978
Grower	3.352	3.525	3.506	3.570	3.796	3.695
Finisher	1.477	1.595	1.668	1.728	1.640	1.762
Total feed cost/bird	5.789	6.078	6.148	6.278	6.408	6.435
LBW (g/chick)	2053	2179	2209	2297	2315	2354
Feed cost *(L.E)* /kg LBW	2.820	2.789	2.783	2.733	2.768	2.734
Total cost *(L.E)*/bird	6.789	7.078	7.148	7.278	7.408	7.435
Total income (LE)/chick	12.318	13.074	13.254	13.782	13.890	14.124
Net revenue LE/chick	5.529	5.996	6.106	6.504	6.482	6.689
EE	0.814	0.847	0.854	0.894	0.875	0.900
Relative EE	100	104.1	104.9	109.8	107.49	110.6

* Total cost (L.E)/ bird = Total feed cost (L.E) /bird + 1 L.E (chick price)

** Price of one Kg live body weight of broiler chicks = 6 L.E.

The economic efficiency values were calculated according to the prevailing market prices for feed ingredients as well as the price of one kilogram live body weight at the end of experimental period which was 6 L.E. The results showed that, there are considerable saving in feed cost/kg live body weight when used betaine either alone or combined with either EP or Vit.C in broiler diets. The data showed that betaine supplementation lowered the feed cost needed to obtain 1kg live body weight; the highest feed cost/kg live body weight was for control treatment (2.82 L.E). The net revenue was also increased by using betaine treatments (T_2, T_3, T_4, T_5 and T_6). The percentage of economic efficiency relative to the total cost (total feed cost + *1 L.E as chick price)* was improved when betaine was added to broilers feed and the best results were recorded with T_4 which consumed diets containing 1500 ppm added betaine and T_6 which fed diets supplemented with 1000ppm betaine and 200ppm Vit.C. 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.

It can be concluded from this study, that the use of betaine supplemented diets (graded levels either alone or in combination with either EP or Vit.C) may be considered as a suitable mean to overcome the depressing effect of heat stress. The dietary betaine level of 1500 ppm or 1000ppm combined with either 1kg of EP/ Ton feed or 200 ppm Vit.C would be preferable for chicks kept at hot conditions, with respect to growth performance and economic efficiency.

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إضافة البيتايين إلي العلائق لتخفيف تأثيرات الإجهاد الحرارى على دجاج اللحم

عمرو حسين عبد الجواد[1]– مسعد محمد على المنيري[1]– علاء الدين عبد السلام حميد[2]

١- قسم الإنتاج الحيواني ــ المركز القومي للبحوث ــ الدقي ــ القاهرة ــ مصر.

٢- قسم إنتاج الدواجن ــ كلية الزراعة ــ جامعة عين شمس ــ القاهرة ــ مصر.

أجريت تجربة لدراسة تأثير استخدام مستويات مختلفة من البيتايين إما وحدة أو مضافاً إليه مخلوط من الإنزيمات التجارية أو فيتامين ج على الأداء الإنتاجي وصفات الذبيحة لكتاكيت اللحم المرباة تحت الظـروف الجوية الحارة في فصل الصيف في مصر. استخدم ١٤٤ كتكوت (هبرد) عمر يوم واحد، تم تقسيمهم إلى ٦ مجموعات بكل منها ٢٤ طائرا في أقفاص فردية (٢٤ مكررا بكل معاملة) تم تغذية مجموعة المقارنـة (١) على علائق توفر الاحتياجات الغذائية لسلالة الـ "هبرد" ولا تحتوى على بيتايين إضافي أمـا المجموعـات رقم ٢، ٣، ٤ فقد غذيت على نفس علائق المقارنة بعد إضافة ٥٠٠، ١٠٠٠، ١٥٠٠ جزء في المليون مـن البيتايين. تم تغذية المجموعة رقم (٥) على علائق المقارنة مضافاً إليها ١٠٠٠ جـزء فـي المليـون مـن البيتايين + ١ كجم مخلوط إنزيمات / طن عليقة مكون من الأميليز والبروتييـز والزايلينيـز فـي حـين أن المجموعة السادسة تغذت على علائق المقارنة مضافاً إليها ١٠٠٠ جزء في المليون من البيتايين + ١ كجـم فيتامين ج ٢٠% / طن عليقة.

أوضحت النتائج عدم تأثر الأداء الإنتاجي للمجموعات المختلفة في نهاية فترة البادىء ولكن مع تقـدم الطيور في العمر (نهاية فترة النامي) تحسن وزن الجسم معنوياً بزيادة نسبة البيتايين إلى ١٥٠٠ جـزء فـي المليون أو ١٠٠٠ جزء في المليون مضافاً إليها مخلوط إنزيمات أو فيتامين ج عن مجموعة المقارنـة فـي حين لم يتأثر معدل الاستهلاك الغذائي ومعامل التحويل الغذائي بالمعاملات المختلفة. وفي نهاية فترة التجربة (٤٩ يوماً) أوضحت النتائج أن المجوعات المغذاة على علائق تحتوي النسبة المرتفعة من البيتـايين (١٥٠٠ جزء في المليون) أو مخلوط من البيتايين مع الأنزيمات أو فيتامين ج قد حققت أحسن معـدل أداء إنتـاجي واعلى عائد اقتصادي.

يستنتج من نتائج هذه التجربة أنه يمكن استخدام البيتايين (مضافاً في صورة منفـردة أو مـع مخلـوط الإنزيمات أو فيتامين ج) كوسيلة فعالة لتقليل التأثيرات الضارة للإجهاد الحراري ويفضل أن يكون مـستوى إضافة البيتايين إما وحده بمعدل ١٥٠٠ جزء في المليون أو يضاف بمعدل ١٠٠٠ جزء في المليون مع إمـا ١ كجم إنزيمات / طن عليقة أو ١كجم فيتامين ج تركيز ٢٠% / طن عليقة.