

## **EFFECT OF PARTIAL OR TOTAL INCLUSION OF BETAINE AND/OR CHOLINE INSTEAD OF ADDED METHIONINE IN BROILER DIETS ON: 2-CARCASS CHARACTERISTICS, SOME BLOOD PARAMETERS AND SENSORY EVALUATION OF MEAT**

**M.M. El-Shinnawy<sup>1</sup>; Sherif, Kh. El<sup>2</sup>; H. F. A. Motawe<sup>3</sup> and M. A. Osman<sup>3</sup>**

<sup>1</sup> *Animal. Prod. Dept. Fac. Agric., Mansoura Univ.*

<sup>2</sup> *Poult. Prod. Dept. Fac. Agric., Mansoura Univ.*

<sup>3</sup> *Regional Center for Food and Feed, Agric. Res. Center, Cairo, Egypt.*

### **SUMMARY**

**T**his study was carried out to investigate the effect of partial or total replacement of added DL-methionine (Met) with betaine (BET) or choline or both in diets of broiler chicks on carcass characteristics, some blood parameters and sensory evaluation of meat. A total number of four hundred and forty day-old straight-run Cobb 500 broiler chicks were randomly, weighed and divided into eleven treatments (forty birds each). Each treatment contained four replicates of ten birds. Three basal diets were formulated as controls according to NRC recommendations and used for the starter, grower and finisher phases (0-12 days, 0.165% added Met.), (12-24 days, 0.135% added Met.) and (24-36 days, 0.090% added Met.), respectively. Treatment one was fed the control ration while the other ten treatments were fed the control ration after partial or total replacement of the added Met. with BET, choline or both. The obtained results revealed that replacement of added Met with BET and/or choline positively affected percentages of carcass yield, total edible parts, breast yield and deboned breast meat while those of heart and abdominal fat were decreased but relative weights of giblets, liver and gizzard were not affected compared with their control counterparts. Chicks fed T10 (50% BET and 50% choline) and T7 (100% BET) had significantly higher serum concentrations of glucose, total protein, albumin and globulin when compared the other dietary treatments. On the other hand total cholesterol, triglycerides, ALT, AST, uric acid and creatinine were decreased due to dietary treatments. Acceptance of sensory evaluation was observed with treatment groups. It could be concluded that replacing added Met by BET, choline or both improved carcass yield, total edible parts, breast yield and sensory meat attributes of broiler chicks.

**Keywords:** *methionine, betaine, choline, broiler chickens, carcass characteristics, some of blood parameters, sensory evaluation.*

### **INTRODUCTION**

Methionine, betaine and choline are all sources of labile methyl groups and play an important role in methylation reactions, and the methyl group metabolism of these three compounds is interrelated as illustrated by (Kettunen *et al.*, 2001). Betaine, is a naturally occurring amino acid derivative found in a variety of feedstuffs of plant and animal origin. Betaine has two primary metabolic roles: it is a methyl group donor and it is an osmolyte that assists in cellular water homeostasis (Petronine *et al.*, 1992).

Recently, betaine has been primarily used as a dietary feed supplement in animal nutrition. Betaine has been indicated to have a number of metabolic and physiological roles in poultry nutrition (Kidd *et al.*, 1997). Betaine contains three methyl groups in its structure and donates these in several metabolic reactions. On a molecular weight basis, betaine contains about 3.75 times the methyl groups of methionine and therefore would be an effective compound to spare dietary methionine as a methyl donor. However, the methionine sparing effect of betaine has been the subject of some controversy. Some

studies have shown positive responses of animals to betaine supplementation in methionine deficient diets, which included improved animal performance and carcass characteristics (Gao *et al.*, 2006).

Moreover, choline is very important to the poultry species such as broiler, laying hens, ducks, quails etc. Where, choline gives the methyl groups necessary for the formation of methionine from homocysteine through being oxidized to betaine (Zhang *et al.*, 2013). Choline is considered as an essential nutrient in poultry diets. Where, choline plays an indispensable role in several biological processes in the body, including building and maintaining cell structure, primarily as a structural component of phospholipids (Summers, 2013). Therefore, choline has three important metabolic roles, for instance as a constituent of phospholipids, prevent fatty liver through hepatic lipid metabolism and as a precursor for acetylcholine. Acetylcholine is the substance responsible for the transmission of nerve impulses which could not be formed without the presence of choline in the body (Zeisel, 2012). These findings have pointed out to the importance of this nutrient in poultry nutrition and production. It is important for researchers to reinvestigate the use of choline in poultry diets. In the past, several studies have looked at choline and betaine for their methionine sparing effects under ideal conditions (Rafeeq *et al.*, 2011).

Betaine, choline and methionine can serve as sources of methyl (-CH<sub>3</sub>) groups. It is well understood that choline may acts as a methyl group donor, but in order to function as a methyl group donor, it needs to be converted to betaine in the mitochondria (Rostagno and Pack, 1996). Many studies have examined the interrelationship between betaine and methionine to determine if these compounds can spare the needs of the chick for methionine with considerable variation in results. Virtanen and Rossi (1995) suggested that the response of broiler growth to betaine was greater than that obtained from the addition of methionine. Other studies have failed to demonstrate that the methionine content of the diet could be reduced by supplementation with betaine (McDevitt *et al.*, 2000; El-Ganzory *et al.*, 2004). However, several studies suggested that addition of betaine may improve breast meat yield (McDevitt *et al.*, 2000). Betaine is indirectly involved in the synthesis of carnitine, which is required for transporting long chain fatty acids across the inner mitochondrial membrane for oxidation and therefore, may result in a leaner carcass.

Most commercial poultry diets are deficient in methionine, so there is a need for supplemental methionine in poultry diets. Thus, continued evaluation of methionine is an important part of work toward the balanced diet formulation. In particular, interrelationships of dietary choline, betaine and methionine need to be further explored in poultry at the metabolic level.

In our relevant complementary paper, we have found that growth performance, mortality rate and economic efficiency of broiler chicks were positively affected when added dietary methionine was replaced with betaine, choline or both (Sherif *et al.* 2017). Therefore, in the present study, an attempt was made to evaluate the effect of dietary inclusion of betaine, choline or both instead of added methionine in broiler diets on carcass characteristics, some blood parameter and sensory evaluation of meat of broiler chicks.

## **MATERIALS AND METHODS**

### ***Chicks and experimental design:***

The present work was conducted in the Poultry Experimental Station of the Regional Center for Food and Feed (RCFF) located in Nubaria, Alexandria, Egypt during May, 2016. Four hundred and forty day-old straight-run Cobb500 broiler chicks obtained from Dakahlia Poultry Company, Meet Ghamr, El-Dakahlia, Egypt, were randomly weighed and divided into eleven dietary treatments as presented in Table 1. Each treatment contained four replicates of ten birds. Birds were kept in battery cages and had free access to feed and water during the experimental period. Water was provided by drip nipples and the broilers were exposed to continuous light (24 hrs daily) throughout the experiment. The averages of initial body weights of the different groups were nearly equal.

All chicks were vaccinated against different diseases according to the vaccination programs adopted in most Egyptian broiler farms in Table (2).

**Experimental diets:**

All chemical analyses were performed in the laboratories of the Regional Center for Food and Feed (RCFF), Agricultural Research Center (ARC), Giza, Egypt. The chemical compositions of yellow corn, soybean meal and corn gluten meal are presented in Table (3)

**Table (1): Replacement levels of methionine with betaine, choline or both in the experimental rations**

Treatments	Betaine%	Choline%	Methionine%
T1	0	0	100
T2	0	33	66
T3	0	66	33
T4	0	100	0
T5	33	0	66
T6	66	0	33
T7	100	0	0
T8	66	33	0
T9	33	66	0
T10	50	50	0
T11	33	33	33

**Table (2): Vaccination program.**

Age(days)	Vaccines	Method used
1	IB brimer	
6	IB+ ND (MA5+Clone30)	Eye drop
10	H <sub>5</sub> N <sub>1</sub>	Subcutaneously injected into the lower back part of the neck
13	Infectious bursal disease (Gumboro D78)	Drinking water
17	IB+ ND (MA5+Clone30)	Drinking water
19	Infectious bursal disease (Gumboro D78)	Drinking water

**Table (3): Chemical Composition of feed ingredients (% , on DM basis)**

	Chemical Composition						
	OM	CP	EE	CF	Ash	NFE	ME(Kcal/kg)
Yellow corn	98.5	8.9	1.4	2.7	1.5	85.5	3350
Soybean meal	94.2	47.5	3.9	7.3	5.8	35.5	2230
Corn gluten meal	98.2	63.5	2.5	2.1	1.8	30.1	3710

The diets were formulated to meet the nutrient requirements of broiler chicks during starting, growing and finishing periods according to the National Research Council (NRC, 1994).

All chicks were fed a starter diet from one to 12 days of age containing 22.77% CP and 3026 kcal ME/kg diet. From 12 to 24 days of age, the birds were switched to a grower diet containing 21.44% CP and 3106.9 kcal ME/kg diet. While, during 24 to 36 days of age, chicks were fed a finisher diet containing 20.07% CP and 3198.6 kcal ME/kg diet (Table 4).

The first experimental group of chicks was fed the control ration which contained only methionine while the other ten groups were fed the control diets in which the added methionine was partially or completely replaced by betaine, choline or both. The control diets contained DL-methionine levels of 1.65, 1.35 and 0.9 g/kg in starter, grower and finisher periods, respectively. Composition and calculated chemical analysis of the basal diets during the three phases of growth are presented in Table (4).

***Carcass characteristics:***

At the end of the experiment (36 days of age), two birds from each replicate were randomly taken and starved for 12 hours, then individually weighed and immediately slaughtered and handheld until complete bleeding to evaluate carcass characteristics. They were defeathered and weighed to get the weight of feathers. The individual weights of carcass with neck, giblets (Liver, empty gizzard and heart) and abdominal fat were estimated and expressed as percent of the live body weight.

The head and shanks were then removed and the carcasses were eviscerated and reweighed to determine the carcass weight.

**Table (4): Composition and calculated chemical analysis of basal diets during the starter, grower and finisher periods**

Ingredient	Starter	Grower	Finisher
Yellow corn	56.003	55.443	58.743
Soybean meal	28.000	28.500	24.800
Corn gluten meal	8.500	8.500	8.500
Sunflower oil	3.000	3.500	4.200
Dicalcium phosphate	2.000	1.850	1.700
Limestone	1.100	0.900	0.795
Vit. & Min. Mixture <sup>(1)</sup>	0.400	0.400	0.400
NaCl	0.400	0.400	0.400
L-Lysine-HCl	0.350	0.290	0.290
DL-Methionine	0.165	0.135	0.090
Choline chloride	0.082	0.082	0.082
Total	100.000	100.000	100.000
Calculated values (% As-fed basis: NRC, 1994)			
CP	22.77	21.44	20.07
EE	3.91	4.42	5.11
CF	3.73	3.75	3.56
ME (kcal/kg)	3026	3106.9	3198.6
Lysine	1.360	1.230	1.130
Methionine	0.580	0.540	0.470
Methionine + Cystine	0.980	0.920	0.840
Calcium	0.980	0.860	0.770
Available P	0.480	0.450	0.410

*(1) Vitamins - minerals mixture supplied per kg of diet: vit. (A), 12000 I.U.; vit. (D<sub>3</sub>), 2000 I.U.; vit. (E), 10 mg; vit. (K<sub>3</sub>), 2 mg; vit. (B<sub>1</sub>), 1 mg; vit. (B<sub>2</sub>), 5 mg; vit. (B<sub>6</sub>), 1.5 mg; vit. (B<sub>12</sub>), 10 µg; Biotin, 50 µg; Pantothenic acid, 10mg; Niacin, 30 mg; Folic acid, 1 mg; Manganese, 60 mg; Zinc, 50 mg; Iron, 30 mg; Copper, 10 mg; Iodine, 1 mg; Selenium, 0.1 mg and Cobalt, 0.1 mg.*

The dressing percentage was calculated by using the following equation:

$$\text{Dressing percentage} = (\text{Carcass weight in grams} / \text{live body weight in gram}) \times 100.$$

***Blood serum constituents:***

At the end of experimental period, blood samples were withdrawn from jugular veins of three birds in each group from in test tubes. The collected samples were immediately centrifuged at 3000 r.p.m. for 15 minutes. Serum was separated and stored at -20C° until the time of analysis. Total protein and albumin were determined according to the method of Doumas *et al.* (1971) and Doumas *et al.* (1981) and globulin concentration was calculated by the difference between total protein and albumin concentrations.

Albumin/globulin ratio was also calculated. Glucose was determined according to the method of Hyvarinen and Nikkla (1962). Liver function was assessed by measuring the activities of Aspartate amino transferase (AST) and Alanine amino transferase (ALT) as described by Reitman and Frankel (1957), total cholesterol, triglycerides and uric acid (Henry, 1964) and creatinine (Bartels and Bohmer, 1971) were determined calorimetrically using commercial kits.

***Sensory evaluation:***

Sensory evaluation is a common and very useful tool in quality assessment of meat products. It makes use of the senses to evaluate the general acceptability and quality attributes of the products.

A sensory panel for the descriptive analysis consisted of 5 assessors experienced in sensory evaluation of different food products. The assessors were selected and trained according to the international standards (ISO, 1993). The sensory evaluation was performed according to a standardized sensory descriptive method (ISO, 1985). The sensory attributes of the boiled chicken meat (breast and thigh) were analyzed. A structured numerical scale was used for evaluation of the intensity of each attribute. The left side of scale corresponding to the lowest intensity of attribute was given a value of 1, and the right side corresponding to the highest intensity was given a value of 7. All sessions were conducted in a climate-controlled sensory analysis laboratory equipped with individual booths.

The samples were prepared by placing them in boiled water and boiling them for 30 min (breast) or 25 min (thigh). The samples were quartered lengthwise and served immediately to panelists along with room temperature water, tea and white bread for neutralization of receptors. The assessors were instructed to clean the palate with water or tea between evaluations of individual samples. The following characteristics were assessed: intensity of aroma, taste, tenderness, color, chewiness, juiciness and overall acceptability. The sample order of presentation to each assessor was randomized.

***Statistical analyses***

Data from all response variables were subjected to one way analysis of variance applying SAS program (SAS, 2004) using General Liner Model. Significant difference among treatment means were separated using Duncan's multiple range procedure (Duncan, 1955) at 5% probability.

## **RESULTS AND DISCUSSION**

***Carcass characteristics:***

Table (5) shows the effect of feeding diets in which added methionine was partially or totally replaced with betaine, choline or both on carcass characteristics for the chicks slaughtered at 36 days of age. The results obtained indicated that feeding the diets containing betaine or choline instead of added methionine positively affected carcass yield of 36-days-old broiler chicks compared with their control group. The highest carcass yield was achieved by chicks fed T7 (100% betaine) and T10 (50% betaine and 50% choline) when compared with other dietary treatments, followed by those fed the diet containing 33% betaine and 66% choline in place of added methionine, and then those fed the diet containing 100% choline in place of added methionine in a descending order, respectively.

The corresponding values for percentages of total edible parts ranged between (carcass yield + giblets weight) percentages 75.18 and 76.98%, where the highest values of chicks were fed on 100% betaine while the lowest values were achieved by that chicks were fed T2 (33% choline and 66% methionine) and the differences were significant ( $P < 0.05$ ) compared with the control group.

On the other hand, the results showed that the complete replacement of methionine with betaine or with 66% betaine and 33% choline led to a significant increase in relative weights of abdominal fat, breast yield and thigh yield ( $p < 0.05$ ) than other treatments and the control.

Several studies suggested that addition of betaine may improve breast meat yield (Schutte *et al.*, 1997; McDevitt *et al.*, 2000). Attia *et al.* (2005) indicated that betaine supplementation significantly improved the percentage of carcass yield in chicks. Similar observations have been reported by Nofal *et al.* (2014) who stated that dietary supplementation with betaine improved carcass yield, breast and giblets percentages than the control group.

Our results are in concordance with the findings of Jahanian and Rahmani (2008) and Neoh and Ng (2012), who reported that dietary betaine supplementation improved carcass yield and breast percentage as well as decreased abdominal fat. Similar observation was reported Vitanen and Rosi (1995), who found that added dietary betaine was more efficient than DL-Methionine in supporting breast meat yield.

These results may be due to the function of betaine which can increase breast meat percentage via its primary metabolic roles, firstly as a methyl group donor and secondly as an osmolyte that assists cellular water homeostasis (Konca *et al.*, 2008). In this regard, Hammer and Baltz (2002) reported that betaine is considered to be the most effective osmoprotectant among other organic osmolytes such as glycine and glutamine.

The obtained results are in contrast with those stated by Lukic *et al.* (2012), who indicated that substitution of added methionine with betaine had no significant differences effects on carcass quality, dressing percentages or the amount of abdominal fat in broiler carcass.

Betaine is indirectly involved in the biosynthesis of carnitine which is required for transporting the long-chain fatty acids across the inner mitochondrial membrane for oxidation (De Ridder and Van Dam, 1975) and therefore, may result in a leaner carcass, which is more attractive by many consumers. As shown in Table 5, percentages of abdominal fat of broilers were significantly ( $P < 0.05$ ) reduced as a result of dietary supplementation of betaine. The decrease of abdominal fat of broilers fed betaine-supplemented diets in the present study may be due to increased hepatic synthesis of carnitine and enhanced activity of the hormone-sensitive lipase in the abdominal fat, as reported by Zhan *et al.* (2006). The results obtained are in agreement with those obtained by El-Ganzory *et al.* (2004), who found no significant variations in broiler liver percentage in response to supplemental betaine. Esteve-Garcia and Mack (2000) suggested that betaine supplementation may improve carcass yield. The present results are consistent with the findings of Zhan *et al.* (2006). The abdominal fat pad of broilers usually represents a waste product and added dietary betaine may decrease the carcass fat of broilers, as reported by Saunderson and Mackinlay (1990). In the other hand, Schutte *et al.* (1997) suggested that betaine has no significant influence on abdominal fat deposition in broiler chickens. This observation is in contrast to the data of Sun *et al.* (2008), who reported that supplementation of betaine to replace 25% of total methionine decreased abdominal fat yield, the reported differences in literature reported results could be related to management and environmental conditions.

Although betaine is involved in lipid metabolism, a reduction in carcass fat in poultry as a result of betaine supplementation is not clearly documented and more research is needed to help clarify this issue.

In this respect, Wang *et al.* (2004) suggested that betaine is more effective in improving carcass quality. These results reflected that methionine and betaine may interact with the lipid metabolism by stimulating the oxidative catabolism of fatty acid via their role in carnitine synthesis, thus offering a potential for reduced carcass fatness in commercial production (Schutte *et al.*, 1997; Konca *et al.*, 2008). These studies indicated that growth of different tissues in broiler chickens responded to betaine supplementation differently.

#### **Blood serum constituents:**

Blood serum constituents of broiler chicks are presented in Table 6. All studied blood serum constituents were significantly affected by dietary replacing added dietary methionine with betaine, choline or both. However, serum total protein and albumin were significantly increased by increasing level of replacing added dietary methionine with betaine, choline or both as compared to the control, while globulin was significantly increased in broiler chicks fed T7 (100% betaine), T8 (66% betaine plus

33% choline) and T10 (50% betaine plus 50% choline) when compared with other dietary treatments. Albumin / globulin ratio was significantly increased for treatment 10 compared with those fed the control diet, whereas, it was insignificantly higher in broiler chicks fed 100% betaine or T3 (66% choline plus 33% methionine).

These results may be due to the function of betaine which may produce an increase in muscle cell proliferation, or may increase availability of methionine, making it available for protein synthesis rather than being used as a methyl donor (Zhan, 2000). The improvement in serum total protein, albumin and globulin due to replacing added dietary methionine with betaine, choline or both may be an indication to its role as a methyl donor rather than for protein metabolism (Remus *et al.*, 2004). These results are in agreement with those obtained by Matthews and Southern (2000), who found that dietary betaine supplementation increased plasma total protein and albumin of broilers under heat stress. Also, (Rama Rao *et al.* (2011) reported that betaine supplementation enhanced the concentrations of protein and globulin in serum of broilers.

Triglycerides and total cholesterol were significantly decreased by feeding diets in which added methionine was partially or totally replaced with betaine, choline or both (Table 6). The percent decrease in triglycerides levels were 13.15, 13.91 and 18.98 % for broiler chicks fed T10 (50% betaine plus 50% choline), T7 (100% betaine) and T3 (66% choline plus 33% methionine) respectively, and the percent increase in total cholesterol were 27.60, 27.70 and 30.62% for broiler chicks fed T10 (50% betaine plus 50% choline), T3 (66% choline plus 33% methionine) and T9 (33% betaine plus 66% choline), respectively as compared to the control. These results may be due to a major role of betaine in lipid metabolism, which was associated with an enhanced synthesis of methylated compounds in liver and muscle such as carnitine and creatine (Zhan *et al.*, 2006).

**Table (5): Effect of partial or complete replacing added dietary methionine with betaine, choline or both on carcass traits of 36-day-old broiler chicks**

Items	Tr. 1 (control)	Tr. 2	Tr. 3	Tr. 4	Tr. 5	Tr. 6	Tr.7	Tr. 8	Tr.9	Tr. 10	Tr.11
Live body weight (g)	1866.67 <sup>d</sup>	1870.83 <sup>d</sup>	1884.79 <sup>cd</sup>	1898.54 <sup>c</sup>	1876.93 <sup>cd</sup>	1902.92 <sup>c</sup>	1952.50 <sup>b</sup>	1926.25 <sup>bc</sup>	1911.04 <sup>bc</sup>	1980.45 <sup>a</sup>	1897.12 <sup>c</sup>
Carcass traits (%)											
Carcass yield	70.97 <sup>cd</sup>	70.68 <sup>d</sup>	71.08 <sup>cd</sup>	72.41 <sup>b</sup>	71.56 <sup>c</sup>	71.73 <sup>c</sup>	73.04 <sup>a</sup>	72.36 <sup>bc</sup>	72.44 <sup>b</sup>	72.86 <sup>ab</sup>	72.35 <sup>bc</sup>
Liver	2.22 <sup>a</sup>	2.18 <sup>a</sup>	2.08 <sup>bc</sup>	2.12 <sup>b</sup>	2.04 <sup>c</sup>	1.96 <sup>cd</sup>	1.92 <sup>d</sup>	2.08 <sup>bc</sup>	2.16 <sup>ab</sup>	1.90 <sup>d</sup>	2.10 <sup>b</sup>
Gizzard	1.78 <sup>b</sup>	1.80 <sup>ab</sup>	1.70 <sup>bc</sup>	1.80 <sup>ab</sup>	1.64 <sup>cd</sup>	1.82 <sup>a</sup>	1.60 <sup>d</sup>	1.68 <sup>cd</sup>	1.72 <sup>bc</sup>	1.58 <sup>d</sup>	1.74 <sup>bc</sup>
Heart	0.48 <sup>b</sup>	0.52 <sup>ab</sup>	0.42 <sup>d</sup>	0.48 <sup>b</sup>	0.56 <sup>a</sup>	0.46 <sup>bc</sup>	0.42 <sup>d</sup>	0.52 <sup>ab</sup>	0.46 <sup>bc</sup>	0.44 <sup>cd</sup>	0.48 <sup>b</sup>
Giblets	4.48 <sup>a</sup>	4.50 <sup>a</sup>	4.20 <sup>c</sup>	4.40 <sup>ab</sup>	4.24 <sup>bc</sup>	4.24 <sup>bc</sup>	3.94 <sup>d</sup>	4.28 <sup>bc</sup>	4.34 <sup>b</sup>	3.92 <sup>cd</sup>	4.32 <sup>b</sup>
Total edible parts	75.45 <sup>cd</sup>	75.18 <sup>d</sup>	75.28 <sup>d</sup>	76.81 <sup>ab</sup>	75.80 <sup>c</sup>	75.97 <sup>bc</sup>	76.98 <sup>a</sup>	76.64 <sup>b</sup>	76.78 <sup>ab</sup>	76.78 <sup>ab</sup>	76.67 <sup>b</sup>
Abdominal fat	1.77 <sup>a</sup>	1.67 <sup>b</sup>	1.72 <sup>ab</sup>	1.62 <sup>bc</sup>	1.58 <sup>c</sup>	1.48 <sup>cd</sup>	1.42 <sup>d</sup>	1.48 <sup>cd</sup>	1.77 <sup>a</sup>	1.48 <sup>cd</sup>	1.63 <sup>bc</sup>
Breast yield	23.44 <sup>d</sup>	23.41 <sup>d</sup>	23.87 <sup>cd</sup>	24.06 <sup>c</sup>	23.92 <sup>cd</sup>	24.10 <sup>c</sup>	25.68 <sup>ab</sup>	25.30 <sup>b</sup>	24.96 <sup>bc</sup>	25.80 <sup>a</sup>	24.12 <sup>c</sup>
Deboned breast meat	17.74 <sup>d</sup>	17.75 <sup>d</sup>	18.48 <sup>cd</sup>	18.73 <sup>c</sup>	18.97 <sup>c</sup>	19.32 <sup>bc</sup>	21.04 <sup>a</sup>	20.04 <sup>b</sup>	20.06 <sup>b</sup>	20.80 <sup>ab</sup>	19.28 <sup>bc</sup>
Thigh yield	24.62 <sup>d</sup>	24.54 <sup>d</sup>	25.16 <sup>bc</sup>	25.08 <sup>c</sup>	24.88 <sup>cd</sup>	25.36 <sup>b</sup>	25.57 <sup>ab</sup>	25.04 <sup>c</sup>	25.68 <sup>a</sup>	25.68 <sup>a</sup>	25.36 <sup>b</sup>

*a, b, c, d Means at the same row with different superscripts are significantly (P<0.05) different.*



Carnitine stimulates to the transport of long-chain fatty acids across the inner membrane of mitochondria where fatty acid oxidation takes place and its ability to regulate fat metabolism (Wang *et al.*, 2004). In addition, the increased hormone-sensitive lipase activity (Zhan *et al.*, 2006) following dietary replacing added methionine with betaine, choline or both perhaps resulted in reducing lipid deposition (Eklund *et al.*, 2005). These results are in agreement with those obtained by Jahanian and Rahmani (2008), and Su *et al.* (2009) who found that betaine enhanced hormone-sensitive lipase activity and decreased the concentration of plasma triglycerides and cholesterol in broilers and geese compared with control under hot summer condition.

On the other hand, liver enzymes (ALT and AST) were significantly decreased by replacing added methionine with betaine, choline or both as compared to the control. These results are similar to those obtained by Attia *et al.*, (2005), who reported that supplementing 1.0 or 2.0 g betaine / kg broiler diet during the starter-grower period (1-56 days of age) resulted in a significant decrease in serum alanine amino transaminase, whereas, Zayed (2012) reported that liver enzymes (AST and ALT) were insignificantly decreased due to betaine supplementation to turkey diet.

Dietary treatments had a slight significant effect on serum glucose concentration when compared to that of their control birds. It is worth noting that blood serum levels of glucose, reported in this study, were in the normal range (180-250mg/dl) that previously reported by Bounous *et al.* (2000). However, Zou and Lu (2002) stated that betaine supplementation induced a significant increase in serum glucose in laying hens.

#### **Sensory evaluation:**

The effects of replacing added dietary methionine with betaine, choline or both on the means of sensory characteristics (aroma, taste, tenderness, color, chewiness, juiciness and overall acceptability) of chicken breast meat samples are shown in Table 7. There were significant differences between control and groups T10 (50% betaine plus 50% choline), T7 (100% betaine), T8 (66% betaine plus 33% choline) and T11 (33% betaine plus 33% choline plus 33% methionine) with respect to overall acceptability attribute ( $p \leq 0.05$ ), with the lowest value was displayed for birds given the T2 (33% choline plus 66% methionine) (7.21) which was considered as the least acceptable for panelists. While T10 group (7.82) was considered as the most acceptable statistically. While means of sensory characteristics of chicken thigh meat samples were significantly different between control and other experimental groups where the highest overall acceptability values were recorded for the T10 (50% betaine plus 50% choline), T7 (100% betaine) and T9 (33% betaine plus 66% choline), with the lowest values for T1 (100% methionine) which was considered as the least acceptable for panelists. The acceptability of all attributes studied ranged between 'like slightly' to 'like moderately'.

In conclusion, partial or complete replacing added dietary methionine with different levels of betaine, choline or both had a positive effect on carcass characteristics, sensory attributes of meat and improved breast meat yield. Further experimentation on the subject may be carried out to establish the fact that added dietary methionine can be partly or totally replaced by other available analogues.



**Table (6): Effect of partial or complete replacing added dietary methionine with betaine, choline or both on concentrations of some blood serum constituents of 36-day-old broiler chicks**

Item	Tr. 1 (control)	Tr. 2	Tr. 3	Tr. 4	Tr. 5	Tr. 6	Tr.7	Tr. 8	Tr. 9	Tr. 10	Tr. 11
Total cholesterol (mg/dl)	137.13 <sup>a</sup>	121.47 <sup>c</sup>	119.10 <sup>cd</sup>	123.44 <sup>bc</sup>	128.78 <sup>ab</sup>	121.00 <sup>c</sup>	118.06 <sup>cd</sup>	124.00 <sup>b</sup>	121.38 <sup>c</sup>	111.10 <sup>d</sup>	129.02 <sup>ab</sup>
Triglycerides (mg/dl)	48.14 <sup>a</sup>	42.40 <sup>ab</sup>	34.80 <sup>cd</sup>	42.18 <sup>ab</sup>	42.00 <sup>b</sup>	41.60 <sup>b</sup>	33.04 <sup>d</sup>	35.01 <sup>cd</sup>	34.86 <sup>cd</sup>	33.40 <sup>d</sup>	40.40 <sup>bc</sup>
Glucose (mg/dl)	198.13 <sup>d</sup>	206.08 <sup>b</sup>	208.40 <sup>a</sup>	204.64 <sup>bc</sup>	201.76 <sup>cd</sup>	201.00 <sup>cd</sup>	206.60 <sup>ab</sup>	205.00 <sup>bc</sup>	200.87 <sup>cd</sup>	205.04 <sup>bc</sup>	207.00 <sup>ab</sup>
Total protein (g/dl)	3.45 <sup>d</sup>	3.47 <sup>d</sup>	4.02 <sup>bc</sup>	4.26 <sup>ab</sup>	3.88 <sup>cd</sup>	3.90 <sup>cd</sup>	4.56 <sup>a</sup>	4.54 <sup>a</sup>	4.26 <sup>ab</sup>	4.29 <sup>ab</sup>	4.11 <sup>b</sup>
Albumin (AL), (g/dl)	1.65 <sup>d</sup>	1.65 <sup>d</sup>	2.04 <sup>bc</sup>	2.12 <sup>b</sup>	1.90 <sup>cd</sup>	1.92 <sup>cd</sup>	2.38 <sup>a</sup>	2.26 <sup>ab</sup>	2.04 <sup>bc</sup>	2.31 <sup>ab</sup>	1.98 <sup>c</sup>
Globulin (GL), (g/dl)	1.80 <sup>d</sup>	1.82 <sup>d</sup>	1.98 <sup>c</sup>	2.14 <sup>bc</sup>	1.98 <sup>c</sup>	1.98 <sup>c</sup>	2.18 <sup>b</sup>	2.28 <sup>a</sup>	2.22 <sup>ab</sup>	1.98 <sup>c</sup>	2.13 <sup>bc</sup>
AL/GL ratio	0.92 <sup>d</sup>	0.91 <sup>d</sup>	1.03 <sup>b</sup>	0.99 <sup>bc</sup>	0.96 <sup>c</sup>	0.97 <sup>bc</sup>	1.09 <sup>ab</sup>	0.99 <sup>bc</sup>	0.92 <sup>d</sup>	1.17 <sup>a</sup>	0.93 <sup>d</sup>
ALT (U/L)	145.18 <sup>a</sup>	142.30 <sup>b</sup>	136.22 <sup>cd</sup>	142.40 <sup>b</sup>	138.50 <sup>bc</sup>	137.40 <sup>c</sup>	135.21 <sup>d</sup>	136.20 <sup>cd</sup>	136.00 <sup>cd</sup>	143.76 <sup>ab</sup>	138.42 <sup>bc</sup>
AST (U/L)	10.75 <sup>a</sup>	9.25 <sup>bc</sup>	8.80 <sup>cd</sup>	9.08 <sup>bc</sup>	10.04 <sup>ab</sup>	9.75 <sup>b</sup>	8.50 <sup>d</sup>	8.80 <sup>cd</sup>	9.00 <sup>c</sup>	8.42 <sup>d</sup>	9.10 <sup>bc</sup>
Uric acid (mmol/L)	6.65 <sup>a</sup>	5.28 <sup>d</sup>	6.18 <sup>ab</sup>	5.75 <sup>bc</sup>	6.26 <sup>ab</sup>	5.55 <sup>c</sup>	5.73 <sup>bc</sup>	5.75 <sup>bc</sup>	6.00 <sup>b</sup>	5.50 <sup>cd</sup>	5.73 <sup>bc</sup>
Creatinine (mg/dl)	0.38 <sup>a</sup>	0.25 <sup>cd</sup>	0.26 <sup>cd</sup>	0.28 <sup>bc</sup>	0.31 <sup>ab</sup>	0.25 <sup>cd</sup>	0.25 <sup>cd</sup>	0.30 <sup>b</sup>	0.28 <sup>bc</sup>	0.26 <sup>c</sup>	0.21 <sup>d</sup>

*a, b, c, d Means at the same row with different superscripts are significantly (P<0.05) different.*

**Table (7): Effect of partial or complete replacing added dietary methionine with betaine, choline or both on sensory parameters of breast and thigh meat of broiler chicks**

Item		Tr. 1 (control)	Tr. 2	Tr. 3	Tr. 4	Tr. 5	Tr. 6	Tr.7	Tr. 8	Tr.9	Tr. 10	Tr.11
Aroma	Breast	6.80 <sup>d</sup>	6.80 <sup>d</sup>	6.75 <sup>c</sup>	6.90 <sup>bc</sup>	6.95 <sup>b</sup>	7.20 <sup>a</sup>	7.04 <sup>ab</sup>	7.20 <sup>a</sup>	6.90 <sup>c</sup>	7.20 <sup>a</sup>	6.90 <sup>bc</sup>
	Thigh	5.96 <sup>d</sup>	6.10 <sup>cd</sup>	6.23 <sup>c</sup>	6.36 <sup>bc</sup>	6.08 <sup>b</sup>	6.76 <sup>ab</sup>	6.82 <sup>ab</sup>	6.12 <sup>a</sup>	6.60 <sup>b</sup>	7.00 <sup>a</sup>	6.90 <sup>a</sup>
Taste	Breast	7.30 <sup>d</sup>	7.32 <sup>d</sup>	7.60 <sup>b</sup>	7.45 <sup>c</sup>	7.60 <sup>b</sup>	7.80 <sup>ab</sup>	8.10 <sup>a</sup>	7.80 <sup>ab</sup>	7.45 <sup>c</sup>	8.14 <sup>a</sup>	7.82 <sup>ab</sup>
	Thigh	6.80 <sup>d</sup>	6.84 <sup>d</sup>	7.04 <sup>cd</sup>	7.20 <sup>bc</sup>	7.18 <sup>bc</sup>	6.95 <sup>cd</sup>	7.40 <sup>b</sup>	7.62 <sup>ab</sup>	7.08 <sup>cd</sup>	8.00 <sup>a</sup>	7.12 <sup>c</sup>
Tenderness	Breast	7.20 <sup>c</sup>	7.65 <sup>b</sup>	7.43 <sup>bc</sup>	7.20 <sup>c</sup>	7.18 <sup>c</sup>	6.85 <sup>d</sup>	7.90 <sup>a</sup>	7.02 <sup>cd</sup>	7.20 <sup>c</sup>	7.80 <sup>ab</sup>	7.40 <sup>bc</sup>
	Thigh	7.42 <sup>c</sup>	7.40 <sup>c</sup>	7.50 <sup>bc</sup>	7.50 <sup>bc</sup>	7.12 <sup>d</sup>	7.80 <sup>a</sup>	7.67 <sup>b</sup>	7.36 <sup>cd</sup>	7.70 <sup>ab</sup>	7.72 <sup>ab</sup>	7.14 <sup>d</sup>
Color	Breast	7.43 <sup>b</sup>	7.40 <sup>b</sup>	7.37 <sup>bc</sup>	7.34 <sup>c</sup>	7.40 <sup>b</sup>	7.30 <sup>d</sup>	7.54 <sup>ab</sup>	7.50 <sup>ab</sup>	7.36 <sup>bc</sup>	7.76 <sup>a</sup>	7.30 <sup>d</sup>
	Thigh	6.94 <sup>d</sup>	7.04 <sup>cd</sup>	7.30 <sup>b</sup>	7.10 <sup>c</sup>	7.12 <sup>c</sup>	7.32 <sup>b</sup>	7.56 <sup>ab</sup>	7.20 <sup>bc</sup>	7.80 <sup>a</sup>	7.84 <sup>a</sup>	7.54 <sup>ab</sup>
Chewiness	Breast	7.28 <sup>d</sup>	7.30 <sup>d</sup>	7.28 <sup>d</sup>	7.40 <sup>c</sup>	7.42 <sup>c</sup>	7.50 <sup>bc</sup>	7.77 <sup>b</sup>	7.80 <sup>b</sup>	7.98 <sup>ab</sup>	8.04 <sup>a</sup>	7.28 <sup>d</sup>
	Thigh	7.60 <sup>b</sup>	7.54 <sup>bc</sup>	7.18 <sup>d</sup>	7.44 <sup>cd</sup>	7.50 <sup>c</sup>	7.50 <sup>c</sup>	7.70 <sup>ab</sup>	7.14 <sup>d</sup>	7.70 <sup>ab</sup>	7.80 <sup>a</sup>	7.50 <sup>c</sup>
Juiciness	Breast	7.40 <sup>bc</sup>	6.80 <sup>d</sup>	7.20 <sup>c</sup>	7.12 <sup>cd</sup>	7.41 <sup>bc</sup>	7.60 <sup>b</sup>	8.06 <sup>a</sup>	7.98 <sup>ab</sup>	7.40 <sup>bc</sup>	7.98 <sup>ab</sup>	8.04 <sup>a</sup>
	Thigh	6.86 <sup>ab</sup>	7.08 <sup>d</sup>	7.80 <sup>b</sup>	7.40 <sup>cd</sup>	7.40 <sup>cd</sup>	7.44 <sup>cd</sup>	7.80 <sup>b</sup>	7.70 <sup>bc</sup>	7.40 <sup>cd</sup>	8.08 <sup>a</sup>	7.60 <sup>c</sup>
Overall acceptability	Breast	7.24 <sup>d</sup>	7.21 <sup>d</sup>	7.27 <sup>cd</sup>	7.24 <sup>d</sup>	7.33 <sup>c</sup>	7.38 <sup>c</sup>	7.74 <sup>ab</sup>	7.55 <sup>b</sup>	7.38 <sup>c</sup>	7.82 <sup>a</sup>	7.46 <sup>bc</sup>
	Thigh	6.93 <sup>d</sup>	7.00 <sup>cd</sup>	7.18 <sup>c</sup>	7.17 <sup>c</sup>	7.07 <sup>cd</sup>	7.30 <sup>bc</sup>	7.49 <sup>ab</sup>	7.19 <sup>c</sup>	7.38 <sup>b</sup>	7.74 <sup>a</sup>	7.30 <sup>bc</sup>

*a, b, c, d Means at the same row with different superscripts are significantly (P<0.05) different.*



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## تأثير إدخال البيتاين أو الكولين أو كليهما كلياً أو جزئياً فى علائق كتاكت لحم كبدائل للمثيونين المضاف على: ٢- صفات الذبيحة وبعض مقاييس الدم والتقييم الحسى للحم

محمد محمد الشناوى<sup>١</sup> خليل الشحات الخميسى شريف<sup>٢</sup> هادى فتحى عباس مطاوع<sup>٣</sup> مصطفى أمين عثمان<sup>٣</sup>

<sup>١</sup>قسم إنتاج الحيوان، كلية الزراعة، جامعة المنصورة، المنصورة

<sup>٢</sup>قسم إنتاج الدواجن، كلية الزراعة، جامعة المنصورة، المنصورة

<sup>٣</sup>المركز الإقليمي للأغذية والأعلاف - مركز البحوث الزراعيه

تهدف هذه الدراسة إلى تقييم تأثير الإحلال الجزئى أو الكلى للمثيونين المضاف للعليقة بالبيتاين أو الكولين أو كليهما فى علائق كتاكت اللحم على خصائص الذبيحة، وبعض مقاييس الدم والتقييم الحسى للحم الصدر والفخذ. إستخدم فى هذه الدراسة ٤٤٠ ككتوت عمر يوم واحد من سلالة كب ٥٠٠، وتم وزنها وتقسيمها إلى إحدى عشر معاملة متساوية (٤٠ طائر/ معاملة). وتحتوى كل معاملة على أربعة مكررات كل مكرر عشرة طيور، وتم تكوين العليقة الأساسية لتكون عليقة المقارنة طبقاً لتوصيات NRC سواء للبدائى (صفر - ١٢ يوم تغذية المعاملة الأولى على عليقة المقارنة بينما تم تغذية العشر معاملات الأخرى على عليقة المقارنة بعد الإحلال الجزئى أو الكلى للمثيونين المضاف بالبيتاين أو الكولين أو خليط منهما. وقد أظهرت النتائج أن إستبدال المثيونين المضاف جزئياً أو كلياً بالبيتاين أو الكولين كان له تأثير إيجابى معنوياً على تصافى الذبيحة ومجموع الأجزاء الصالحة للأكل ومحصول الصدر ومحتوى لحم الصدر فى حين إنخفضت قيم القلب ومحتوى دهن البطن وبمقارنة نسبة الكبد والقانصة نجد أنها لم تتأثر مقارنة بمجموع المقارنة. ولقد حققت الكتاكت المغذاه على المعاملة العاشرة (٥٠% بيتاين + ٥٠% كولين) والمجموعة السابعة (١٠٠% بيتاين) زيادة معنوية فى تركيز البروتين الكلى، الجلوبيولين، الجلوكوز والألبومين وعلى الجانب الأخرى إنخفاضاً معنوياً فى الدهون الثلاثية، الكوليسترول، ALT، AST، حمض اليوريك والكرياتين كما أظهرت النتائج قيماً مرتفعة لكل قياسات التذوق الحسى مقارنة بمجموعة المقارنة. وتشير النتائج أن إستبدال المثيونين المضاف بالبيتاين أو الكولين أو كليهما قد أدى إلى تحسين صفات الذبيحة والأجزاء المأكولة وإرتفاع محتوى لحم الصدر ومقاييس التذوق.