

## **IMPACT OF METHIONINE AND BETAINE OR BOTH ON THE PERFORMANCE OF BROILERS FED LOW PROTEIN DIETS: 2- BONE MEASUREMENTS, BLOOD PARAMETERS AND HISTOLOGICAL EXAMINATION**

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### **SUMMARY**

**T**his study aimed to examine the effect of methionine and/or betaine supplementation on bone measurements, some blood parameters, fatty acid differentiation and histological examination of broilers that fed low protein diets. A total numbers of 180 one day old unsexed Hubbard boiler chicks were divided into six treatments (30 birds each). Each treatment contained 3 replicates of 10 birds. Two levels of dietary crude protein (recommended D<sub>1</sub>) control diet, and 2% crude protein (D<sub>2</sub>), treatment diets (T<sub>1</sub>-T<sub>5</sub>) and DL-methionine (MET), or betaine (BET), were added in experimental treatment diets as follows:

- 1-Control; Chicks were fed control diet (D<sub>1</sub>)
- 2-T<sub>1</sub>: Chicks were fed low protein diet, 2% crude protein (D<sub>2</sub>)
- 3-T<sub>2</sub>: Chicks were fed D<sub>2</sub> + 100% MET
- 4-T<sub>3</sub>: Chicks were fed D<sub>2</sub> + 50% MET + 50% BET
- 5-T<sub>4</sub>: Chicks were fed D<sub>2</sub> + 25% MET + 75% BET
- 6-T<sub>5</sub>: Chicks were fed D<sub>2</sub> + 100% BET

All diets (control and T<sub>1-5</sub>) were equal in lysine % and MET add in the T<sub>2</sub> diet up to control diet.

The results indicated that:

- 1- Tibia length was significantly affected by treatments and chicks fed (T<sub>2</sub>) diet gave the lowest significant values compared with control group.
- 2- Blood parameters showed insignificant figures in most parameters. However, AST activity had significant different and the best values were for chicks that fed on T<sub>4</sub> compared to other treatments and control.
- 3- The saturation to unsaturation ratios were improved by betaine and methionine supplementation compared to control group.
- 4- Liver histology showed improvement for birds that fed betaine and methionine compared with control group.

It could be concluded that betaine and methionine have improved bird's health without any adverse effect on liver and these results obviously clear by blood determination. Therefore, MET and BET supplementation has been recommended in low-protein broiler diets without any adverse effect on bird's health.

**Keywords:** *Bone measurements, MET, BET, AST. Sat. /unsat. ratios and liver histology.*

### **INTRODUCTION**

The results of many previous reports demonstrated that chicks which had received low-CP corn soybean meal diets fortified with AA,s performed equally well as those which had received the positive control diet, Holsheimer *et al.* (1992) and Sinovaet *et al.* (2010).

However, due to technological advances some essentials amino acids [methionine, lysine, threonine and tryptophan] have become economically available in recent years and there is a good possibility that others will be commercially available in the future. Recent reports indicated that promising results can be obtained by the use of low-protein, amino acid supplemented diets for laying hens (Keshavaraz and Austic, 2004).

DL- methionine is normally considered to be the first limiting amino acid in poultry diets. In general, amino acid balance and nitrogen retention are improved by methionine supplementation. Hassan *et al.* (2003) using Mandara and Abdalla (2005) using Gimmizah found insignificant difference on final body weight by increasing dietary methionine level in their diets. Hassan *et al.* (2003) observed that increase daily intake of methionine was accompanied by significant improvement in egg production and

feed conversion. Centenary, Abdalla et al. (2005) showed the opposite result. Naulia and Singh (2002) found that using different levels of methionine significantly improved digestibility coefficient of organic matter, crude protein. On the other hand, El-Husseiny et al. (2005) observed that DL- methionine supplementation had no significant effect on digestibility coefficient values of nutrients.

Betaine, the common term 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).

Furthermore, betaine promotes intestinal microbes against osmotic variations and improves microbial fermentation activity, which in turn, may enhance nutrient digestibility (Ratriyanto et al., 2009).

Bone is a dynamic tissue influenced by physiological, nutritional, and physiological factors such as mechanical stress and physical activities. Overall, the economic cost associated with bone problems in poultry can add up to several hundred million dollars a year, Rath et al. (2000). In adult birds, supplementing diets with vit.D, Ca, P, phytase, Vit C, and Vit. K as well as protein energy enrichment diets, may be beneficial in maintaining bone mass and thereby, bone strength. Because bone formation is an early event related to growth, nutritional interventions directed towards producing better bone mass may be helpful.

Therefore, the aim of this study was to investigate the effect of methionine and/or betaine supplementation in the low-protein diets on the some physiological parameters, bone measurements, fatty acids differentiation of the breast meat, and liver histology of broiler chickens.

## MATERIALS AND METHODS

The Present experiment was carried out at the poultry experimental unit, Agricultural experiment and Research Station at Shalakan, Faculty of Agriculture, Ain Shams University.

### ***Birds, diets and management:***

A total numbers of 180 one-day old unsexed Hubbard broiler chicks were divided into six treatments (30 birds each), each treatment contained 3 replicates of 10 birds each. Chicks were reared in an environmentally controlled room with a continuous light and fans for ventilation and were fed starter diet from 0 to 3 weeks of age and grower diet from 4 weeks of age to the end of the experiment at 5 weeks of age (corn-soy bean meal diet). Feed and water were supplied ad libitum. Two levels of dietary crude protein (Recommended (D<sub>1</sub>) control diet and -2% crude proteins, treatment diets (T<sub>1</sub>-T<sub>5</sub>) and DL-Methionine (MET) or Betaine (BET) were added in experimental treatment diet as follows:

- 1- Chicks were fed the control diet (D<sub>1</sub>) (Control).
- 2- Chicks were fed - 2% crude protein (D<sub>2</sub>) (T<sub>1</sub>).
- 3- Chicks were fed D<sub>2</sub> + 100% MET (T<sub>2</sub>)
- 4- Chicks were fed D<sub>2</sub> + 50% MET + 50% BET (T<sub>3</sub>)
- 5- Chicks were fed D<sub>2</sub> + 25% MET + 75% BET (T<sub>4</sub>)
- 6- Chicks were fed D<sub>2</sub> + 100% BET (T<sub>5</sub>)

The added MET up to control diets in the T<sub>2</sub> (0.20 and 0.12) diets was partially (50% and 75%) or completely (100%) replaced by BET in diets T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>. All diets (control and T<sub>2</sub> – T<sub>5</sub>) were equal in lysine %. BET was added as 97% - dry crystalline Betafin BT. Composition and calculated analysis of the experimental diets are presented in Table 1.

The vaccination program adopted according to standard commercial guidelines.

### ***Blood parameters:***

Individual blood samples were collected in dry clean centrifuge tubes from the slaughtered birds and plasma was separated by centrifugation at 3000 rpm for 15 min. and assigned for subsequent determination. Plasma samples were stored at (-20°C) in a deep freezer until the time of chemical determination. Biochemical analyses of blood plasma were conducted in poultry physiology laboratory, Faculty of Agriculture, Ain Shams University. Quantitative determination of blood was included the following: total protein, albumin, globulin [determined by subtraction the value of albumen for the sample from its corresponding value for total protein], total lipid, triglycerides, total cholesterol, uric acid, AST, and ALT. All biochemical parameters of blood were calorimetrically determined using commercial diagnosing kits [Produced by Bio-Diagnostics Company, Egypt].

### ***Bone measurements:***

Right tibia were removed and cleaned from soft tissues, then weighed and length, width of each was measured using caliper to the nearest mm. The tibia were dried (105°C for 3 hrs.), weighed and tibia Seedor Index were calculated according to Seedor *et al.* (1991).

***Fatty acids analysis:***

Fatty acid methyl ester (FAME) was prepared by using sulfuric acid in methanol as esterifying reagent (AOAC, 1965). The FAME was analyzed by using gas chromatography (GC) Mode, Shimadzu 4c/ (PFE) equipped with FID detector and glass column 2.5 x 3 mm. The calibration and identification of fatty acid peaks was carried out by comparison with retention times of known authentic standards. The fatty acid results are expressed as weight percentages.

***Histological examination:***

During slaughtering time, 3 birds of each treatment were taken for histological studies. Liver samples were taken, immediately fixed in 10% buffered formalin solution for histological technique. All sections (4-5 µm tick) were stained with haematoxylline and eosin (H & E) stain according to Bancroft *et al.* (1994) sections were examined under light microscope and then photographed using computerized program.

***Statistical analysis:***

Data were statistically analyzed according to ANOVA procedures of SAS (SAS Institute, 2002). Means differences were compared using Duncan's Multiple Range Test (Duncan, 1955).

## **RESULTS AND DISCUSSION**

***Bone Measurements:***

Data for some bone measurements are summarized in Table (2). Experimental treatments with BET (T<sub>3-5</sub>) had no significant effect on studied parameters compared with control. The corresponding values for wet tibia weight (g) ranged between 9.54 and 10.64, Tibia length (mm) ranged between 8.30 and 8.53 (mm) and Tibia seedor index (SI) ranged between 0.59 and 0.62.

On the other hand, the chicks fed T<sub>2</sub> diet gave the lowest figures of 9.37 g, 7.93 mm and 0.59 for tibia weight, tibia length and SI and the differences were significant (P<0.05) compared with control group in tibia length only.

It is appropriate to consider that through strategic nutritional manipulations, it may be possible to increase or preserve bone mass and to maintain bone strength. Exploring the nutritional requirements that would improve collagen crosslinks may be useful in improving bone quality in meat type poultry, Rath, *et al.* (2000).

These results have indicated that betaine and methionine may be having important role on Ca metabolism, but it could not say that without more investigation on this side.

***Blood parameters:***

The results concerning on the effect of different treatments on some blood parameters are shown in Table (3).

Although all of blood parameters have not significant different affected by different dietary treatments, AST activity has significantly different (P<0.05), and the lowest value was for chicks that fed on T<sub>4</sub> compared to other treatments and control.

Concerning of total protein, albumin, globulin, and A/G ratio were not significantly affected by dietary treatments, but numerically T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub> for plasma albumin have the highest values compared to other treatments and control group. Also, globulin level for chicks that fed T<sub>4</sub> was the lowest values compared to control and other treatments. On the other hand, T<sub>1</sub> and T<sub>3</sub> have the lowest values for the A/G ratio compared to other treatments. That's means methionine and betainesupplementations have an important in improving resistance to stress as well as the immune function (Zulkifli *et al.*, 2004). These results are in agreement with those obtained by Zhan (2001) who reported that betafin [betaine] addition significantly improved the immune response and alleviated the response of body temperature.

This finding was similar to those obtained by Park *et al.* (2006) and Tollbaet *al* (2008) who reported that concentration of plasma total protein and albumin as well as globulin were not significantly affected in layers fed diets supplemented with betaine for 16 weeks under hot climate stress. Also, the same results

were reported by Bunchasaket *et al.* (2005) and Attia *et al.* (2005), but contrary to our results, El-Ganzory *et al.* (2004) found that methionine supplementation increased serum albumin.

Concerning kidney function, uric acid concentrations were not significantly different affected by different treatments, but numerically T<sub>4</sub> and T<sub>5</sub> have the highest values compared with other treatments and control groups and these results reflected that betaine and methionine supplementation have been affected on the protein metabolism and consequently increased kidney excretion.

Lipid metabolism was measured to investigate the effect of different treatments on lipid profile in broiler. Table (3) indicated that there were not significant different among different treatments and control, but numerically T<sub>4</sub> has the lowest values for total lipid, triglycerides, and cholesterol compared to other treatments. Also T<sub>2</sub> and T<sub>5</sub> have the lowest values for cholesterol concentration. These results indicated that betaine and methionine have caused reduction in plasma total lipids, triglycerides, and total cholesterol. That's mean, methyl donor treatments regulate lipid metabolism in chickens. This reduction in plasma lipids could be due to the ability of methyl donor to reduce the transcription of lipogenesis genes especially fatty acid synthase as mentioned by Xing *et al.*, (2011). The inhibition of lipid biosynthesis in plasma and adipose tissues explained the reduction of abdominal fats and improvement of feed conversion ratio of chickens. At the same findings, Rudolph *et al.*, (2007) indicated that methyl donor compounds especially betaine regulate lipid metabolism via regulation of transcription of fatty acid synthesis genes.

Regarding liver function, as fore mentioned AST activity has significantly different as affected by different treatments and the lowest value which for birds that fed on T<sub>4</sub> and these results indicated that betaine and methionine supplementation have improved of liver function, although ALT activity was not significantly different among different treatments. Methionine and betaine supplementation have improvement in liver function especially for broilers that fed on T<sub>2</sub> and T<sub>5</sub> which recorded the lowest values.

These treatments have important effect on reduction of liver enzymes in plasma. It could be contributed to their ability strengthen the hepatocellular membrane by its membrane.

Stabilizing action or to a counter action of free radicals by their antioxidant property (Ganesan *et al.*, 2010). Also, betaine could induce antioxidant defensive enzyme which reduce lipid peroxidation of hepatocyte membrane and reduce the leakage of liver enzymes to plasma. These results in close to Konca *et al.* (2008) and Zayed (2012) who reported that liver enzymes AST and ALT were insignificantly decreased due to betaine supplementation to turkey diet.

In conclusion, reducing of nitrogen in broiler chickens with supplementation of betaine and essentials amino acid [methionine] could play a significant role in reducing of nitrogen pollution from poultry manure. Therefore, reducing dietary protein level in the diet is a good strategy to lower ammonia emissions from broiler chickens excreta and improving environmental condition around the birds. So, we may be fed a broiler chick low protein diet with betaine and methionine supplementation without adverse effect on performance, health and improvement in economic efficiency.

#### ***Effect of different treatments on breast meat fatty acid differentiation:***

Table (4) showed the effect of different treatments on saturated and unsaturated fatty acids. The data indicated that betaine and methionine supplementation have increased the C18.1, C18.2 and C18.3 concentrations compared with other treatments and control group and this increasing very clear especially in C18.1 [Oleic acid]. Also, the saturated to unsaturated ratio was improved by betaine and methionine supplementation compared with control group. These results indicated that methionine and betaine may interact with lipid metabolism by stimulating the oxidative catabolism of fatty acid via its role in carnithine synthesis. Thus offering a potential for reduced carcass fatness in commercial production and that is benefit for chickens and consequently human's health.

#### ***Histological examinations:***

From Fig. 1 to Fig. 11 indicated the effect of different treatments on liver. Histopathological examination of liver from different group revealed:

##### ***Control:***

Liver showed moderate to severe degenerative and necrobiotic changes of hepatocytes (Fig.1) resulting in distortion and disorganization of hepatic cords and sinusoidal dilatation (Fig. 2).

Multifocal areas of hepatic necrosis of variable size with replacement of the necrotic tissue by mononuclear cells were commonly found scattered throughout the hepatic tissue (Fig. 3 & 4).

Portal fibroplasia and dilatation of portal blood vessels associated with cholangitis and intense mononuclear cell infiltration of the bile duct wall were commonly observed (Fig. 5 & 6).

**T<sub>2</sub>&T<sub>3</sub>:**

Less severe and less extensive were noticed. In addition, Paracentral mononuclear cell infiltration (Fig. 7) and cholangitis with dilatation of portal blood vessels (Fig. 8) were observed.

**T<sub>4</sub>:**

Liver of such group revealed moderate necrobiotic changes, congestion of portal blood vessels, distortion of hepatic cords and sinusoidal dilatation (Fig. 9) associated with foci of hepatic necrosis with replacement of the necrotic cells by mononuclear cells scattered throughout the hepatic tissue (Fig. 10).

**T<sub>5</sub>:**

Liver showed diffuse vacuolar degeneration of hepatocytes (Fig. 11). In general, histological observations support the performance where growth performance of treatment groups have significantly improved without any adverse effects on liver histology and these results obviously clear in blood parameters determination.

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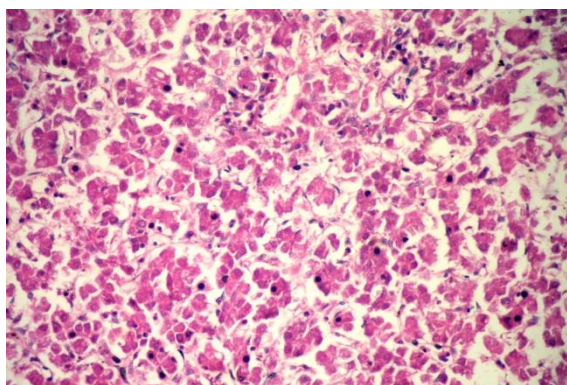


Figure 1

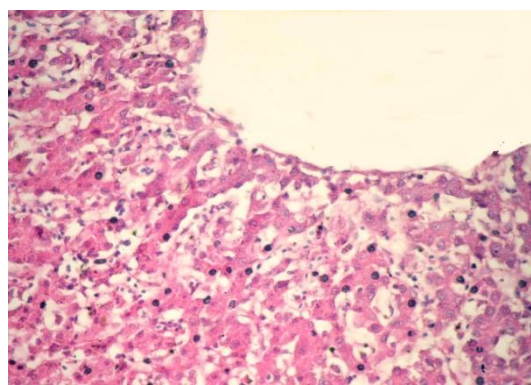


Figure 2

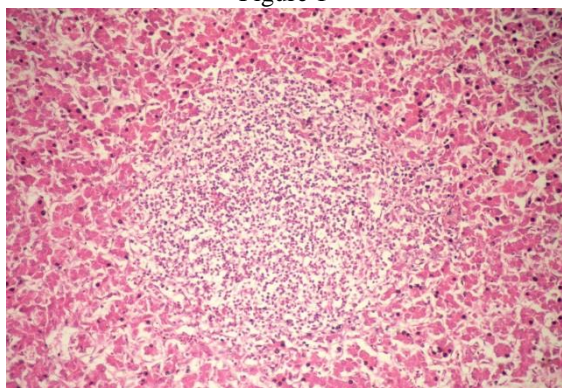


Figure 3

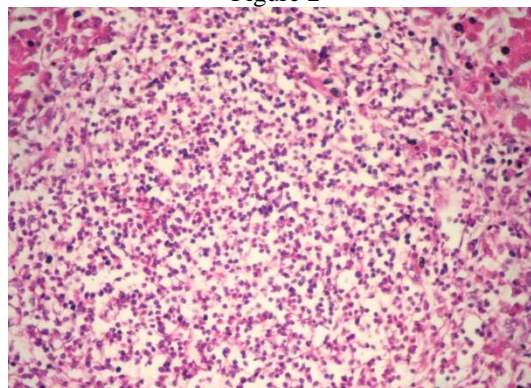


Figure 4

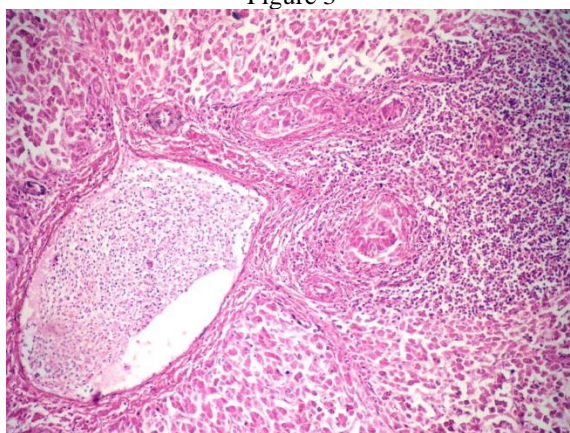


Figure 5

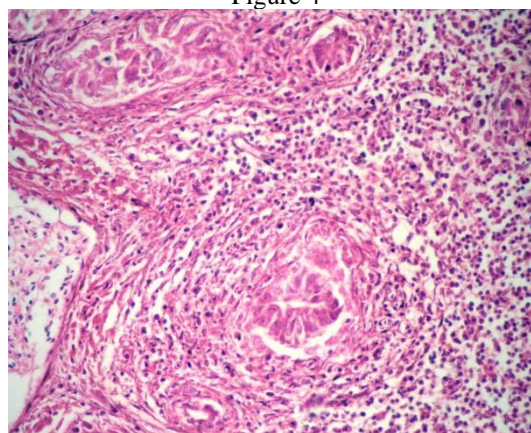


Figure 6

**T.s. of liver (H& Ex 100).**

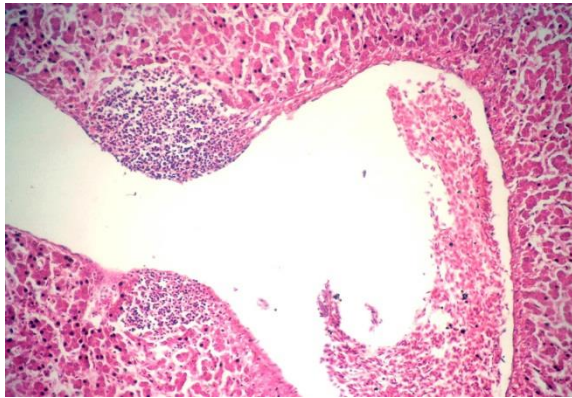


Figure 7

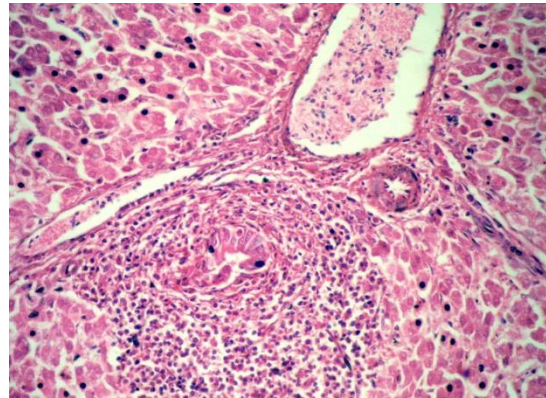


Figure 8

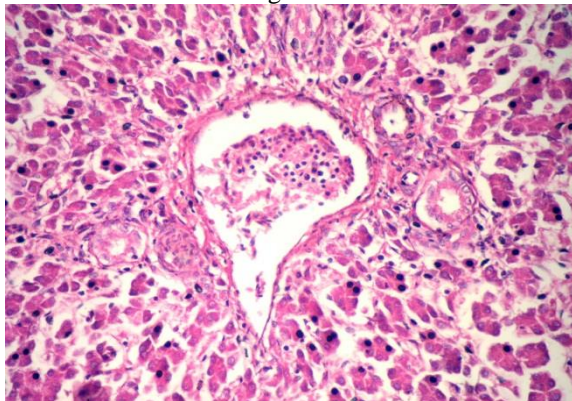


Figure 9

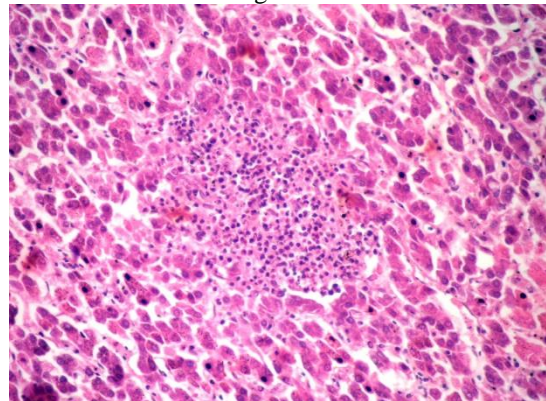


Figure 10

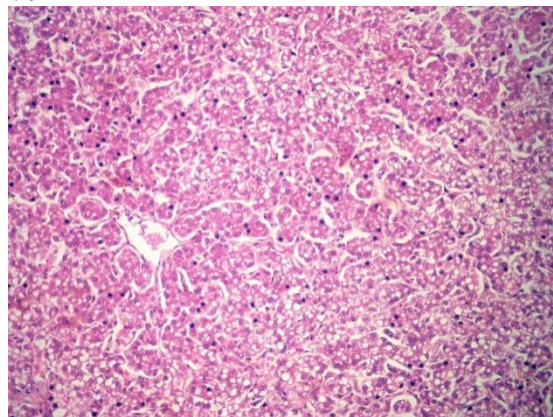


Figure 11

**T.s. of liver (H& Ex 100)**

**Table (1). Composition and calculated chemical analysis of the starter and grower experimental basal diets**

Ingredients %	Starter (0-3 weeks)		Grower (4-5 weeks)	
	Control	T <sub>1</sub> -T <sub>5</sub> diets*	Control	T <sub>1</sub> -T <sub>5</sub> diets*
Yellow corn	46.45	54.44	54.44	60.0
Soybean meal (44%)	36.20	30.15	30.15	25.29
Full fat soya	9.00	9.00	9.00	9.00
Soya + Sunflower oil	3.65	2.00	2.00	1.5
Mono calcium phosphate	1.85	1.68	1.68	1.68
Limestone	1.60	1.48	1.48	1.48
Salt (NaCl)	0.40	0.40	0.40	0.40
DL-Methionine	0.34	0.20	0.20	0.12
L-Lysine HCL	0.08	0.22	0.22	0.10
Vitamin & Min. Mix **	0.30	0.30	0.30	0.30
Choline chloride 50%	0.13	0.13	0.13	0.13
Total	100.00	100.00	100.00	100.00
Calculated chemical analysis ***				
Crude protein %	22.93	20.93	20.93	19.06
ME (Kcal/kg)	3030	3029	3029	3055
Calcium %	1.04	0.95	0.95	0.95
Available phosphorus %	0.56	0.56	0.56	0.51
Lysine %	1.48	1.40	1.40	1.21
Methionine %	0.72	0.55	0.55	0.45
Methionine + cysteine %	1.09	0.87	0.87	0.77

\*All diets (control and T<sub>2</sub>-5) were equal in lysine % and MET add in the T<sub>2</sub> diets up to control diets was partially 50%, 75% or 100% replaced by BET in diets T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>.

\*\*Vitamin & mineral premix supplied each kg of feed with: Vit. A: 12000 IU; Vit. D<sub>3</sub> 2000 IU; Vit. E: 40 mg; Vit. K<sub>3</sub>: 2 mg; Vit. B<sub>1</sub>: mg; Vit. B<sub>2</sub>: 4mg; Vit. B<sub>6</sub>: 1.5 mg, Pantothenic acid: 10 mg; Vit. B<sub>12</sub> 0.01 mg; Folic acid: 1.5 mg; niacin: 20 mg; biotin: 0.05 mg; Zn: 55 mg; Fe: 30 mg; I: 1 mg; Se: 0.1 mg; Mn: 55 mg; Cu: 0.5g; Co.: 0.25 mg and ethoxyquin 3000 mg.

\*\*\* Calculated according to feed composition tables for animal and poultry feedstuffs used in Egypt (2001).

**Table (2). Effect of feeding different experimental diets on some of bone measurements.**

Items	Dietary treatments						SE	Sig.
	control	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>		
Wet tibia weight (g)	10.61	10.59	9.37	9.54	10.64	9.57	0.7	NS
Tibia length (mm)	8.53 <sup>a</sup>	8.40 <sup>ab</sup>	7.93 <sup>b</sup>	8.33 <sup>ab</sup>	8.47 <sup>ab</sup>	8.30 <sup>ab</sup>	0.16	*
Tibia width (mm)	0.63	0.62	0.63	0.62	0.58	0.57	0.03	NS
Tibia seador index (SI)	0.61	0.60	0.59	0.59	0.62	0.59	0.04	NS

a,b Means in the same raw with different superscripts are significantly ( $P \leq 0.05$ ) different.

N.S.: non-significant

**Table (3). Effect of feeding different experimental diets on some plasma parameters.**

Items	Dietary treatments						SE	Sig.
	Control	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>		
Total protein (g/dl)	6.72	7.75	6.08	6.63	5.95	5.93	0.54	NS
Albumin (g/dl)	3.99	3.94	4.02	4.09	4.08	3.87	0.13	NS
Globulin (g/dl)	2.73	3.80	2.06	2.54	1.87	2.06	0.51	NS
*A/G ratio	1.46	1.04	1.95	1.61	2.18	1.88	0.44	NS
Uric acid (mg/dl)	3.87	3.55	3.80	4.60	5.16	6.46	0.97	NS
Total lipids (mg/dl)	428.23	497.03	416.37	461.44	332.14	574.14	95.88	NS
Triglycerides (mg/dl)	83.33	60.66	68.33	88.00	66.33	81.33	6.00	NS
Cholesterol (mg/dl)	183.50	210.23	182.43	206.30	180.16	175.83	21.63	NS
AST (RFU/ml)	27.50 <sup>ab</sup>	41.00 <sup>a</sup>	26.07 <sup>ab</sup>	27.65 <sup>ab</sup>	21.50 <sup>b</sup>	36.66 <sup>ab</sup>	4.75	*
ALT (RFU/ml)	15.11	18.04	12.86	14.98	14.18	12.86	1.34	NS

a,b Means in the same raw with different superscripts are significantly ( $P \leq 0.05$ ) different.

N.S.: non-significant



Table (4). Effect of different treatments on the fatty acids differentiation.

Fatty acids	Different treatments					
	Control	T1	T2	T3	T4	T5
Caprylic acid C8	1.099	0.726	2.549	2.071	1.160	1.536
Myristic acid C14	0.478	0.517	0.495	0.533	0.548	0.491
Palmitic acid C16	25.919	25.423	25.952	26.424	25.004	25.168
Palmitoleic acid C16:1	3.571	4.183	3.589	3.225	3.752	3.899
Heptadecanoic acid C17	0.142	0.128	0.183	0.124	0.156	0.147
Stearic acid C18	6.557	6.407	6.789	7.703	6.679	6.261
Oleic acid C18.1	2.338	39.167	36.224	35.302	35.719	32.114
Linoleic acid C18.2	16.631	19.119	16.303	17.044	19.312	18.581
Linolenic acid C 18.3	0.674	0.775	0.691	0.711	0.813	0.841
Behenic C22	0.151	0.108	0.164	0.176	0.181	0.244
Ermic C22:1	0.183	-	0.197	0.199	0.215	0.233
Sat/unsat ratio%	1.47	0.53	0.63	0.66	0.56	0.61

تأثير إضافة الميثيونين و/أو البيتاين إلى علائق منخفضة البروتين على: 2- قياسات العظم - صفات الدم - اختبارات هستولوجية لبدارى التسمين

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تهدف الدراسة إلى تقييم تأثير استخدام كلاً من الميثيونين و/أو البيتاين على قياسات العظم وبعض التأثيرات الفسيولوجية المتعلقة بالدم لبدارى التسمين المغذاة على علائق منخفضة البروتين.

حيث استخدم عدد (180) ككتوت سلالة الهارد عمر يوم تم وزنها ووزعت عشوائياً على ستة مجاميع غذائية كالاتى:

- 1- العليقة الأولى ككتوت
- 2- العليقة الثانية -2% بروتين خام (23% بادئ، 21% نامى)
- 3- العليقة الثالثة مثل العليقة الثانية مع (100% ميثيونين)
- 4- العليقة الرابعة مثل العليقة الثانية مع (50% ميثيونين + 50% بيتاين)
- 5- العليقة الخامسة مثل العليقة الثانية مع (25% ميثيونين + 75% بيتاين)
- 6- العليقة السادسة مثل العليقة الثانية مع (100% بيتاين)

جميع العلائق متساوية المحتوى فى الليسين وإضافة الميثيونين فى العليقة الثانية حتى مستوى الكنترول (العليقة الأولى).

وكانت أهم النتائج المتحصل عليها كالاتى:

- 1- طول عظمة الساق تأثرت معنوياً بالمعاملات الغذائية وسجلت الكناكيت المغذاة على العليقة الثالثة أقل القيم بالمقارنة بالكنترول.
- 2- صفات الدم أظهرت عدم التأثير بالمعاملات الغذائية ولكن نشاط إنزيم AST تأثر وكانت أقل القراءات للطيور المغذاة على العليقة الخامسة.
- 3- تحسنت نسبة الأحماض الدهنية المشبعة للغير مشبعة المتواجدة فى لحم عضلة الصدر للدجاج المغذى على البيتاين والميثيونين مقارنة مع الكنترول.
- 4- الطيور المغذاة على البيتاين والميثيونين أظهرت تحسن فى قطاعات هستولوجى للكبد مما يدل أن البيتاين والميثيونين أدو إلى تحسن فى وظائف الكبد وخلاياه مقارنة مع الكنترول وهذا التأثير واضح من خلال التحسن فى أنزيمات الكبد. لهذا توصى الدراسة باستخدام كلاً من الميثيونين والبيتاين فى علائق بدارى التسمين بدون أى تأثير ضار على صحة الطيور بل العكس أدى إلى تحسین واضح من خلال تحاليل الدم وقطاعات هستولوجى للكبد.