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Trace Minerals Utilization and Production Efficiency of Broiler Chickens Fed Different Levels of Yeast Culture and Methionine

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ABSTRACT

A study was conducted to determine the effect of supplemental dietary yeast culture *Saccharomyces cerevisiae* and methionine (cyc-meth) on trace mineral utilization and performance of broiler chicks. 400 Lohman chicks were randomly distributed into 16 pens (25 chicks/pen). Each pen was considered as a replicate and every 4 replicates received one of the following treatments: Control (C): basal diet of corn and soybean meal; T1, control diet + 2 kg cyc-meth; T2, control diet + 3 kg cyc-meth; and T3, control diet + 4 kg cyc-meth.

Cyc-meth supplementations significantly ($P<0.01$) increased the inorganic percentage and zinc concentration ($P<0.05$) in liver (dry and wet weight) of chicks from T1, T2 and T3 compared with the control group. Significantly lower concentration of cobalt ($P<0.001$) and higher copper concentration ($P<0.05$) in liver of chicks were observed from T2 and T3 compared to control and T1 groups, but no significant ($P>0.05$) effect of treatment was observed on manganese concentration. Moreover, chicks from T1 and T3 showed a significantly higher ($P<0.05$) final body weight and dressing percentage compared to C and T2. However, feed intake was significantly increased ($P<0.05$) with the addition of cyc-meth. Moreover, the partial budget showed that the addition of 2 kg cyc-meth to broiler diet had a positive net return over the control of 0.032 US$/ chicken and $ 0.334 US$ of marginal rate of return.

In conclusion, the addition of cyc-meth to broiler diets improved growth rate, feed intake, zinc and copper utilization, and negatively affected the absorption of cobalt. However, the responses were not consistent with increasing the level of yeast culture in broiler diets.

Keywords: Broiler, Feed intake, Growth, Trace minerals, Yeast-methionine.

INTRODUCTION

Saccharomyces cerevisiae is one of the most widely commercialized types of yeast culture fed to farm animals. Understanding the role of the yeast cultures *(Saccharomyces cerevisiae)* in animal diets to enhance their productivity and health is very crucial. Intense research efforts have attempted to understand the basic mechanism, which accounts for the beneficial effects of yeast cultures in all groups of farm animals. However, the most successful research programs studied the effect of yeast culture on ruminant animals' health and productivity. Most research results indicated that supplementation of live yeast cells (*Saccharomyces cerevisiae*) to the ruminants' feed ration may improve feed intake (Williams et al., 1991), weight gain (Greive, 1979; Fallon and Harte, 1987), digestion (Wohlt et al., 1991), influence ruminal fermentation and the population of microorganisms in the rumen, especially cellulolytic bacteria (Harrison et al., 1988; Dawson et al., 1990) increase ruminal pH (Williams, 1989) and mineral absorption and metabolism (Petersen et al., 1987).

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The research in the area of poultry, especially broiler, is very limited and very few studies were published regarding the effect of feeding yeast culture on their performance, especially in term of mineral utilization. Furthermore, the scientific literature related to broiler has been inconsistent in reported findings. Ignacio (1995) and Onifade et al. (1998) reported that feeding yeast to chicks improves body weight gain and feed conversion ratio. In disagreement, Madriqal et al. (1993) reported popposite results with regards to body weight gain. Onifade et al. (1999) reported that yeast supplementation to broiler improves feed conversion but not growth rate. In contrast, Kanat and Calialar (1996) found that feeding yeast culture to broiler effectively increased body weight gain without affecting feed/ gain ratio.

Methionine is the first limiting sulfur amino acid in the corn- soybean poultry diets. Few scientific researches regarding the requirements of methionine and other sulfur amino acids by broiler chicks were reported with inconsistency in findings. Hickling et al. (1990) and Jensen et al. (1989) reported that increasing feeding levels of methionine and other sulfur amino acids improved the general performance of broiler chicks. Others (Mendonca et al., 1989) reported that increasing the level of dietary protein to broiler chicks led to an increase in requirements of methionine and other sulfur amino acids. On the other hand, Kassim and Suwanpradit (1996) found that increasing the feeding levels of methionine and other sulfur amino acids to broiler chicks did not affect their performance, independent of protein levels in the diets.

In general, trace minerals bioavailability can be affected by many dietary factors. In ruminants, yeast culture *(Saccharomyces cerevisiae)* supplementations improved N, Zn, Fe and K balances (Wiedmeier et al., 1987; Cole et al., 1992; Williams et al., 1994). These findings suggest that yeast supplementation to broilers' diet may be possible to improve trace mineral bioavailability and utilization and consequently reduce environmental pollutions.

Because of that, the objective of the present study is to determine whether yeast culture (*Saccharomyces cerevisiae*) and methionine have an effect on several trace minerals utilization and growth performance of broiler chicks reared in the Jordanian environment and under the Jordanian production system.

MATERIALS AND METHODS

Chicks Husbandry

400 one-day-old unsexed Lohman™ chicks were randomly distributed into four equal treatments, each with four replicates (25 chicks/ replicate) as a completely randomized design with an equal number of chicks in each replicate. The chicks were reared on wood shaving in pens in an open house. The area of each pen was 3 m^2 (2mX1.5m). Treatments were: diet 1: basal diet (corn-soybean diet); diets 2, 3 and 4 were basal diet plus 2, 3 and 4 kg cyc-meth, respectively. Each kg of cyc- methionine consists of: *Saccharomyces cerevisiae* $1.0x10^9$ c.f.u. up q.s. and 8.6 g DL- Methionine (Choong Ang Biotech Co., LTD, Soul, Korea). The recommended level of adding cyc-meth for broiler ranges from 1 to 4 kg per ton. Feed and water were offered *ad libitum* and light duration was 23 hours/day. All diets were formulated by using the BLP88™ computer program for formulating least cost rations. All diets in the starter and finisher periods were formulated to be isocaloric and isonitrogenous according to NRC (1994) recommendations as shown in Table 1. The chicks were fed starter diets from day one to 28 days of age and finisher diets from 29 days to 49 days. Live weight, feed consumption, feed conversion ratio and mortality rate were recorded weekly until the 7th week of age. At the end of the experiment, 5 chicks from each pen were

slaughtered for calculating dressing percentages (hot carcass weight divided by live weight), and liver samples were collected. The liver samples were dried and wet digested by acids according to AOAC (1990) for copper (Cu), zinc (Zn), manganese (Mn) and cobalt (Co) analysis by using atomic absorption spectrophotometery.

Partial Budget Analysis

Partial budget analysis was performed to evaluate the economic advantage of using different levels of cyc-meth to broiler diet. It involves tabulating the costs and benefits of a small change in the farm practice of feeding (CIMMYT, 1988; Shapiro et al., 1994). The method entails calculating net return (*NR*); *i.e.* the amount of money left when total variable costs (*TVC*) are subtracted from the gross returns (*GR*):

$NR = GR - TVC$

Total variable costs include the costs of all inputs that change due to the change in production technology. The most important criterion in deciding whether or not to adopt a new technology is the change in net return (ΔNR). This amount is the difference between the change in gross return (ΔGR) and the change in total variable costs (ΔTVC)

$\Delta NR = \Delta GR - \Delta TVC.$

The marginal rate of return (*MRR*) measures the increase in net income (ΔNR) associated with each additional unit of expenditure (ΔTVC):

$MRR = \Delta NR / \Delta TVC.$

The *MRR* measures the effect of additional investment in new technology on additional net returns (CIMMYT, 1988). In order to perform the partial budget analysis, the variable costs and benefits were worked out as follows: 1). Poultry on all treatments have similar labor, veterinary, fuel and oil, rent and water costs; 2). The index price for 1kg cyc-meth was 2.86US$, and for the 1kg feed cost was 1.263US$; 3). The current price of 1kg of live poultry was 1.37US$; 4). Costs of supplementation of feed intake were: 1.535$ in C, 1.567 in T1, 1.421$ in T2 and 1.499$ in T3; 5). Costs of supplementation of feed cyc-meth were: 0.009$ for 2 kg, 0.013 for 3 kg and 0.017$ for 4 kg, but zero in C.

Table (4) uses partial budgeting to illustrate how to estimate the economic impact of the supplementation of 2 kg, 3 kg and 4 kg cyc-meth/ ton feed.

STATISTICAL ANALYSIS

Data regarding the chickens' performance and mineral concentrations in liver were analyzed by using SPSS™ version (10.0) as a complete randomized design. The replicate pen of broiler served as the experimental unit for data analysis. The linear model was:

$$Y_{ij} = \mu + t_i + E_{ij}$$

Yij= dependent variable.

μ = overall mean.

ti= effect of i^{th} level of cyc-methionine as a treatment.

Eij= random error associated with the observation.

The Duncan multiple range test was used to determine differences among means (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Trace Mineral Concentrations in Liver

Liver samples have proved useful in anticipating mineral deficiencies in livestock, because they are considered as the storage organ of certain minerals (Underwood and Suttle, 1999). In this study, the inorganic, organic and dry matter percentages in livers from all treatments are shown in Table 2. Results showed a significant (P<0.01) higher inorganic percentage in livers of all groups fed cyc-meth (T1, T2 and T3) compared with the control (1.34, 1.52 and 1.56 vs 1.19%, respectively) with no significant (P<0.05) differences between treated groups, except a numerical increase with increasing the level of cyc-meth supplementation. Moreover, there was no significant effect of treatment on the organic and dry matter percentages in chicks' livers compared with the control group.

Trace minerals are the most important elements basically required for all biochemical processes in the animal's body. Despite their low requirements, severe or marginal deficiencies in these trace minerals can cause substantial economical losses by affecting animal performance and health. Therefore, liver samples were collected, prepared, and analyzed for copper (Cu), zinc (Zn), cobalt (Co) and manganese (Mn) on dry and wet weight basis. Figures 1, 2, 3 and 4 show the effects of treatments on concentrations of these trace minerals in the liver.

Zinc concentrations in the livers of chicks from T1, T2 and T3 were significantly higher (P<0.01) on dry matter basis when compared to the control group (89.13, 93.1, 87.0 vs 79.14 ppm, respectively; Figure 1). Significantly (P<0.05) higher concentrations of Cu were found in the livers of chicks from T2 and T3 compared with chicks from T1 and the control group. However, no significant differences were observed (P>0.05) when comparing the control and T1 groups (Figure 2). In contrast, no significant (P>0.05) effect of treatment was found on the Mn concentrations in the livers of all treated groups compared with the control group (Figure 3). Moreover, Co concentrations in the livers of chicks from T2 and T3 were significantly lower (P<0.05) compared with the control and T1 groups (Figure 4). Puls (1988) reported that high intake of sulfur amino acids by chicks reduced the absorption and utilization of cobalt.

In general, trace minerals bioavailability can be affected by many dietary factors including feed additive, interaction with dietary nutrients and ingredients, choice of response criteria, choice of standard source and chemical form and solubility of the mineral. In ruminants, yeast culture *(Saccharomyces cerevisiae)* supplementation improved N, Zn, Fe and K balances (Wiedmeier et al., 1987; Cole et al., 1992; Williams et al., 1994). Moreover, Bradely and Savage (1995) reported a significant increase (P<0.05) in the retention of some minerals (Ca, P, Mn and K) in turkey chicks when fed live yeast culture compared with the control and autoclaving yeast culture groups. Zhang (2005) reported a greater villus height and VCR (villus height/crypt depth ratio) in the ileal mucosal tissues as a result of feeding yeast compared with the control, leading to increase the absorption of nutrients in the small intestinal tract. Therefore, the results of this experiment support the general idea that yeast culture plays an important role in increasing the absorption and retention of some minerals and other nutrients by modifying the conditions in the digestive tract and improving the ileal mucosal development of poultry and consequently reduce the soil contamination through their excreta.

General Performance of Chickens

Effects of experimental diets on body weight, feed intake and feed conversion of broiler chicks during 0 to 4 weeks (starter), 4 to 7 weeks (finisher), and overall 7 weeks of age are presented in Table 3. During the 0 to 4 weeks period, supplementing cyc-meth to broiler chicks resulted in a significantly lower (P<0.10) body weight in all groups compared to the control, but no significant differences were found between treated groups and the control in terms of feed intake (P= 0.91) and feed conversion (P=0.38). Moreover, during the period from 4 to 7 weeks, chicks from the treated groups with cyc-meth showed a significantly (P<0.05) higher feed intake, but no significant effect (P>0.05) on the body weight gain and feed conversion ratio compared with the control group. Chicks from T1 group showed a significant higher (P<0.05) final body weight compared with chicks from the control and T3 groups (2133 vs 2040 and 2000 g, respectively) and did not differ compared to chicks from

T2 group (2080 g). On the other hand, a significant higher ($P<0.05$) total feed intake was reported for all chicks fed different levels of cyc-meth compared with the control.

In contrast, Ignacio (1995) and Onifade et al. (1998) reported that feeding yeast to chicks improves body weight gain and feed conversion ratio. On the other hand, Madriqal et al. (1993) and Karaoglu and Durdag (2005) are in disagreement with our findings regarding body weight gain. Onifade et al. (1999) reported that yeast supplementation to broiler improves the feed conversion but not the growth rate. In contrast, Kanat and Calialar (1996) found that feeding yeast culture to broiler effectively increased body weight gain without affecting feed/ gain ratio, which agrees completely with our findings in this study. Moreover, Karaoglu and Durdag (2005) reported no significant effect of yeast on average feed consumption (1-49 days) and feed conversion (1-49 days), which partially agrees with our findings.

In general, several researchers (Valdivie, 1975; Oyofo et al., 1989; Newman, 1994; Spring et al., 2000; Zhang et al., 2005) reported that yeast culture improved the efficiency of immune system, improved the intestinal lumen health, and increased digestion and absorption of nutrients, leading to improve the general performance and health of broilers. So, the mortality rate in this study illustrated numerically lower percentages (1.6 to 2.1%) in treated groups compared with the control (3.2%) which may support the above idea of improving health and immunity.

One of the main concerns of the poultry industry is to obtain a higher dressing percentage and consequently increase the edible portion and profit. In this study, significant higher dressing percentages were found in chicks from T1 and T3 when compared with the control and T2 groups (71.9 and 72.1 vs 71.3 and 71.58%, respectively; Figure 5), which means that adding cyc-meth improves dressing percentage. This finding is inconsistent with Karaoglu and Durdag (2005) who reported no significant effect of yeast supplementation to broiler diet on the hot and cold carcass weight and yield and consequently on the dressing percentage. Probably, the increase in the dressing percentage in our study may be caused by the addition of methionine to yeast which increased the daily methionine intake by chicks in the treated groups. Bunchasak et al. (2006) findings supported this explanation by reporting an increase in broiler dressing carcass and a decrease in abdominal fat when methionine was fed above the NRC requirements. Moreover, the breast meat percentage was significantly improved by methionine supplementation. Therefore, methionine supplementation can significantly improve the broiler meat yield and dressing percentage, which is in agreement with our findings and those of a previous research by Moran (1994).

Economical Evaluation

According to the partial budget analysis, 2 kg of cyc-meth added to one ton feed returned a higher profit margin than the addition of 3 kg of cyc-meth and 4 kg of cyc-meth per ton feed (Table 4). For example, the net returns from 2 kg of cyc-meth added to one ton feed gave a marginal rate of return of 0.334 compared with the control (0% of cyc-meth). On the contrary, the marginal net returns from the groups fed 3 kg and 4 kg cyc-meth/ ton were negative (-$1.930 and -$0.392, respectively).

The present result suggests that the addition of 2 kg of cyc-meth/ ton is potentially more profitable than either 3 kg of cyc-meth/ ton or 4 kg of cyc-meth per ton without negative effect. The above result was attributed to the higher growth rates and final weights of chicks in the treated groups.

CONCLUSION

This experiment appears to provide evidence that feeding of *Saccharomyces cerevisiae* yeast culture with methionine (cyc-meth) to broiler chicks with a level of 2 kg cyc-meth/ ton diet could improve growth rate, feed intake, zinc and copper utilization and profit. Moreover, higher levels of cyc-meth are economically unfeasible in term of final body weight and negatively affect the absorption of cobalt. Nevertheless, further research is required to investigate the mechanism of *Saccharomyces cerevisiae* yeast culture with methionine in affecting trace mineral absorption and utilization.

Table 1. The ingredients and chemical composition of the starter and finisher diets.

Ingredient	Starter	Finisher
Corn	56%	64%
Soybean meal (44% CP)	36.61%	30.17%
Corn Oil	3.2%	2.5%
DCP[1]	1.7%	1.2%
Calcium Carbonate	1.65%	1.45%
D-L lysine	0.08%	0.005%
D-L Methionine	0.19%	0.075%
Salt	0.3%	0.3%
Choline chloride	0.07%	0.1%
Mineral and Vit. Premix.[2]	0.2%	0.2%
Total	100	100
Calculated composition		
Crude protein (%)	21	18.9
Metabolizabe energy (kcal/kg)	2948.5	3016.8
Methionine (%)	0.518	0.378
Lysine (%)	1.21	0.983
Cysteine (%)	0.342	0.314
Ca (%)	1.12	0.92
Total P (%)	0.70	0.59
Non phytate P (%)	0.449	0.348

[1]Dicalcium phosphate (21.5% calcium and 18.7% phosphorus).

[2]Mineral and vitamin premix (Vapco): Every kg of premix contained the following : vitamin A= 8000000 I.U.; Vit. D3= 1500000 I.U.; Vit. E= 1000 I.U.; vitamin K3= 2000 mg; Vit. B1= 500 mg; vit. B6= 200 mg; vit. B12= 8 mg; Folic acid = 50 mg: Calcium pantothenate = 4000 mg and Nicotinamide = 6000 mg. Minerals: Fe_2SO_4= 550 mg; Mn_2SO_4= 450 mg; Zn_2SO_4= 230 mg; Cu_2SO_4= 40 mg; Ca_2CO_3= 14 mg; cobalt chloride= 100 mg..

Table 2. Effect of treatment on liver inorganic matter, organic matter and dry matter percentages.

	Dry matter		**Inorganic matter**		**Organic matter**	
Treatment	**X**	**SE**	**X**	**SE**	**X**	**SE**
C[a]	26.03	0.27	1.188[a]	0.08	24.85	0.31
T1[b]	26.59	0.45	1.34b	0.07	25.25	0.47
T2[c]	25.52	0.31	1.52b	0.07	24.38	0.34
T3[d]	26.52	0.39	1.56b	0.06	24.96	0.38
Significancy	NS		.002		NS	

Within each column, means with common letter are not statistically different ($P<0.05$).

NS: not significant

[a] control group

[b] treated group with 2 kg cyc-meth /ton diet

[c] treated group with 3 kg cyc-meth /ton diet

[d] treated group with 4 kg cyc-meth /ton diet

Table 3. Effect of feeding yeast culture and methionine on chickens' performance.

Treatments Measurements	C[a]		T1[b]		T2[c]		T3[d]		P value
Body weight (g)									
Starter	681.3[a]	47.4	612.0[b]	43.1	625.3[b]	58.5	644.3[b]	29.5	0.10
Finisher	1358.7	118.7	1521.3	111.7	1374.7	161.5	1435.7	104.6	0.43
Final BW	2040.0[a]	124.9	2133.3[b]	87.3	2000.0[a]	220.0	2080.0[b]	105.8	0.05
Feed intake (g)									
Starter	1355.7	98.7	1362.3	41.9	1308.7	124.9	1349.7	117.0	0.91
Finisher	2506.0[a]	224.3	2708.6[b]	149.8	2624.7[b]	163.3	2694.0[b]	100.0	0.05
Total FI	3862.0[a]	141.8	4053.0[b]	137.6	3933.3[b]	167.6	4043.7[b]	122.3	0.05
Feed conversion									
Starter	2.11	0.02	2.39	0.24	2.24	0.27	2.22	0.10	0.39
Finisher	1.82	0.12	1.78	0.21	1.92	0.17	1.88	0.14	0.73
Overall FC	1.89	0.06	1.90	0.13	1.98	0.17	1.95	0.12	0.81

Within each row, means with common letter are not statistically different (P<0.05).
[a] control group
[b] treated group with 2 kg cyc-meth /ton diet
[c] treated group with 3 kg cyc-meth /ton diet
[d] treated group with 4 kg cyc-meth /ton diet

Table 4. Partial budget analysis for adding different levels of cyc-methionine.

	C			*T1*			T2			T3		
Gross returns			**$2.798**			**$2.926**			**$2.743**			**$2.853**
Feed costs	**SFC[1]**	**FFC[2]**	**TC[3]**	**SFC[1]**	**FFC[2]**	**TC[3]**	**SFC[1]**	**FFC[2]**	**TC[3]**	**SFC[1]**	**FFC[2]**	**TC[3]**
Corn	$0.212	$0.441	$0.652	$0.212	$0.483	$0.695	$0.204	$0.468	$0.672	$0.204	$0.480	$0.685
SBM	$0.174	$0.261	$0.435	$0.175	$0.286	$0.461	$0.168	$0.277	$0.445	$0.168	$0.284	$0.452
Oil	$0.043	$0.062	$0.105	$0.044	$0.068	$0.111	$0.042	$0.066	$0.108	$0.042	$0.067	$0.109
DCP	$0.009	$0.011	$0.020	$0.009	$0.012	$0.021	$0.008	$0.012	$0.020	$0.008	$0.012	$0.020
Calcium Carbonate	$0.001	$0.001	$0.002	$0.001	$0.001	$0.002	$0.001	$0.001	$0.002	$0.001	$0.001	$0.002
D-L Lysine	$0.003	$0.000	$0.003	$0.003	$0.000	$0.003	$0.003	$0.000	$0.003	$0.003	$0.000	$0.003
D-L Methionine	$0.010	$0.007	$0.017	$0.010	$0.008	$0.018	$0.010	$0.008	$0.018	$0.010	$0.008	$0.018
Salt	$0.000	$0.001	$0.001	$0.000	$0.001	$0.001	$0.000	$0.001	$0.001	$0.000	$0.001	$0.001
Choline chloride	$0.002	$0.006	$0.009	$0.002	$0.007	$0.009	$0.002	$0.007	$0.009	$0.002	$0.007	$0.009
Minerals and Vit. .Premix	$0.007	$0.012	$0.019	$0.007	$0.014	$0.020	$0.007	$0.013	$0.020	$0.007	$0.013	$0.020
CYC-Methionine	$0.000	$0.000	$0.000	$0.009	$0.009	$0.017	$0.013	$0.013	$0.026	$0.017	$0.017	$0.034
Total variable costs	$0.460	$0.803	$1.263	$0.471	$0.888	$1.359	$0.457	$0.865	$1.322	$0.462	$0.892	$1.353
Net return			**$1.535**			**$1.567**			**$1.421**			**$1.499**
NROC*	-		-			**$0.032**			**-$0.114**			**-$0.035**
MRR**	-		-			**$0.334**			**-$1.930**			**-$0.392**

[1] Starter diet cost [2] Finisher diet cost [3] Total feed intake cost
NROC*, *Net return over control* *MRR**, Marginal rate of return*

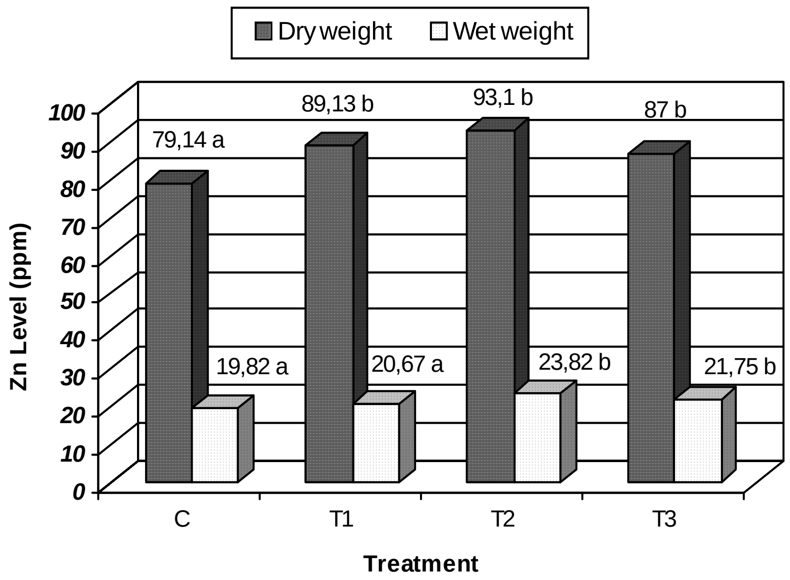

Figure 1. Effect of treatment on zinc concentration in liver.

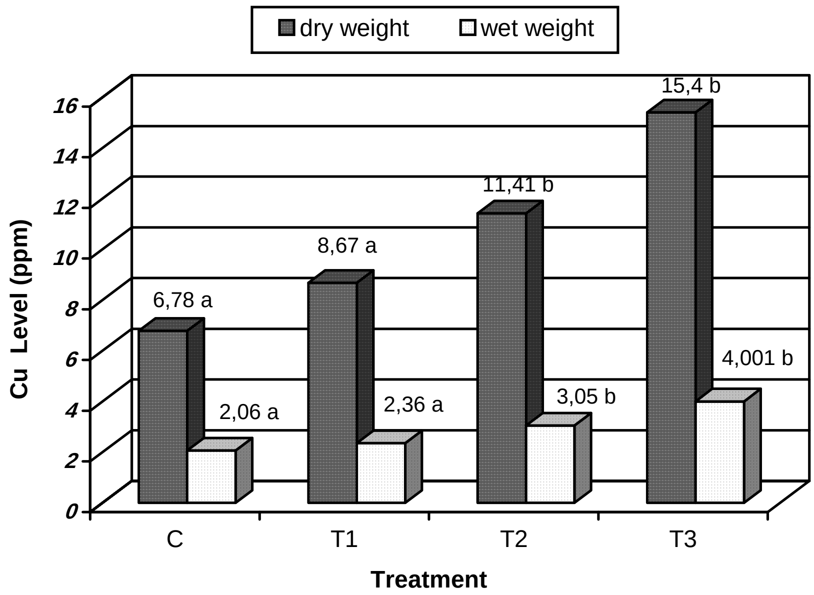

Figure 2. Effect of treatment on copper concentration in liver.

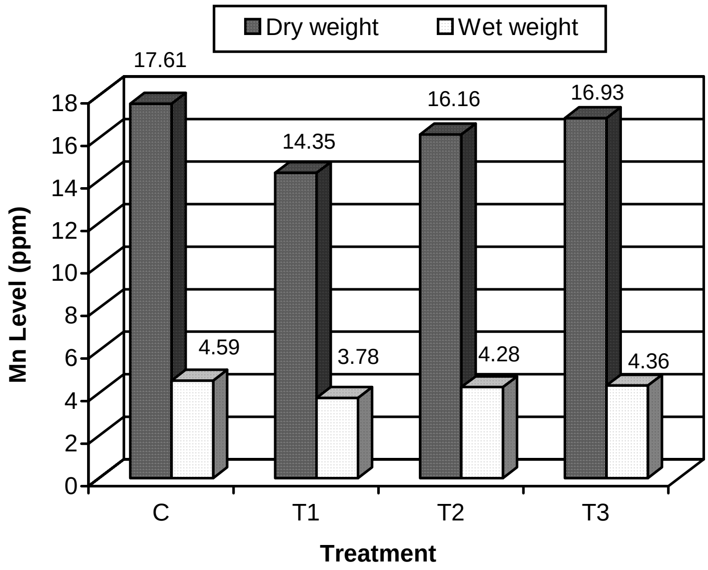

Figure 3. Effect of treatment on manganese concentration in liver.

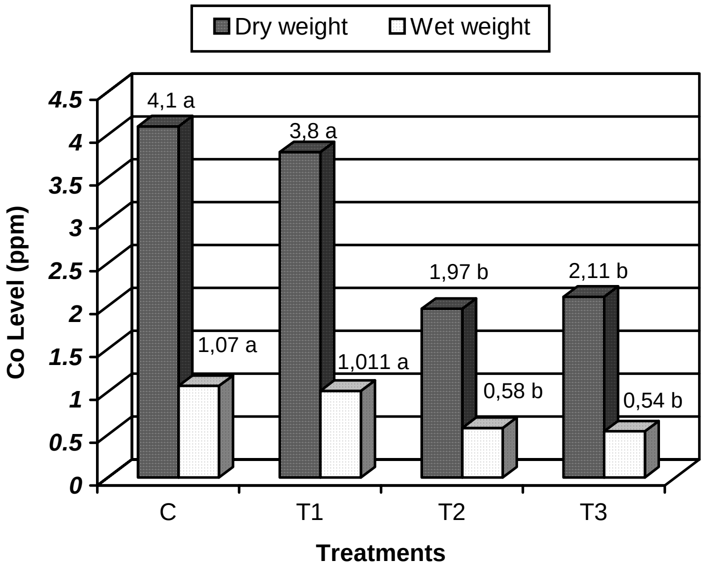

Figure 4. Effect of treatment on cobalt concentration in liver.

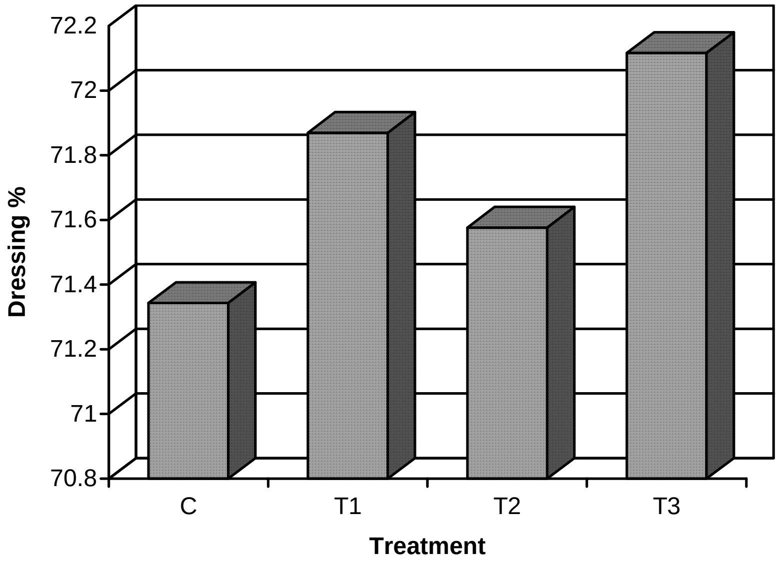

Figure 5. The effect of treatment on the dressing percentage of chickens.

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الكفاءة الإنتاجية والاستفادة من العناصر المعدنية الصغرى للدجاج اللاحم بعد تغذيته بمستويات مختلفة من الخميرة والميثايونين

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ملخـص

تم تنفيذ هذا البحث لدراسة تأثير إضافة الخميرة والحمض الأميني (الميثايونين) بمستويات مختلفة في الاستفادة من العناصر المعدنية الصغرى وأداء الدجاج اللاحم. تم توزيع 400 صوص لوهمان على 16 مكرراً (25 صوصاً/ مكرراً) بواقع أربعة مكررات لكل معاملة. كانت المعاملات كما يلي: 1. الشاهد (خلطة ذرة وصويا)، معاملة 1(T1)- خلطة الشاهد + 2 كغم خميرة + ميثايونين، معاملة (2) (T2) خلطة الشاهد + 3 كغم خميرة + ميثايونين، معاملة (3) (T3) خلطة الشاهد + 4 كغم خميرة + ميثايونين.

إضافة الخميرة والميثايونين لخلطات الدجاج اللاحم أثرت معنوياً ($p<0.05$) في نسبة الرماد وتركيز الخارصين في الكبد. وانخفض تركيز الكوبلت معنوياً ($p<0.05$) وزاد تركيز النحاس في كبد الدواجن في المعاملتين T2 وT3 مقارنة بـ T1 والشاهد. كما زاد استهلاك العلف في جميع المجاميع بإضافة الخميرة والميثايونين.

في الخلاصة، تؤدي إضافة الخميرة والميثايونين لخلطات الدجاج اللاحم إلى تحسين النمو واستهلاك العلف والاستفادة من عنصري الزنك والنحاس، كما تؤثر سلباً في امتصاص الكوبلت.

الكلمات الدالة: دجاج لاحم، استهلاك علف، نمو، معادن صغرى، الخميرة والميثايونين.

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