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Research Article
Influence of Dietary Methionine, Folic Acid and Cyanocobalamin and Their Interactions on the Performance of Broiler Breeder

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Abstract

Objective: The experiment was conducted to examine the response of the local broiler female line (Cairo B-2), a new strain of the native Egyptian breed White Baladi chicken females which crossed with Arbor Acres grandparent female line males, to certain dietary nutrients including methionine (Meth), folic acid (FA) and vitamin B_{12}. **Methodology:** The experiment was designed in a 2×2×2 factorial arrangement from 53-64 weeks of age. Seventy two females and twenty four males were randomly assigned to 8 groups of 9 hens and 3 roosters in 3 replicates each. The birds were housed individually and artificially inseminated with pooled semen every 4 weeks. **Results:** The results indicated that feeding diet containing 0.25% Meth, 13.0 mg kg^{-1} FA and 0.15 mg kg^{-1} B_{12} showed the best egg weight, egg mass, feed conversion ratio, hatchability and 1 day old chick weight followed by the diet containing 0.25% Meth, 13.0 mg kg^{-1} FA and 0.03 mg kg^{-1} vitamin B_{12}. Neither egg quality parameters nor blood parameters were significantly affected by either levels of Meth, FA or B_{12} or their interactions, except for Haugh units and hemoglobin ($p \leq 0.05$). The high level of FA improved Haugh units, while the high level of Meth improved hemoglobin. **Conclusion:** The best productive and reproductive performance were obtained when Cairo B-2 broiler breeders were fed the diet containing 0.25% Meth, 13.0 mg kg^{-1} FA and either 0.03 or 0.15 mg kg^{-1} vitamin B_{12}.

Key words: Broiler breeders, methionine, folic acid, cyanocobalamin

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The local broiler female line (Cairo B-2) is a new strain of the native Egyptian breed White Baladi chicken females which crossed with Arbor Acres grandparent female line males[1]. This strain had been started at 2003 with continuous selected generation for the high weight at 6 weeks of the progeny and now is reach to the 11th generation. Nassar *et al.*[1] started a selection improvement program at the Poultry Farm, Animal Production Department, Faculty of Agriculture, Cairo University, Giza, Egypt, to develop the Cairo B-2 line as a local broiler female line. The phenotypic selection of this line was based on the individual's 6 weeks body weight. Male and female broilers with the highest body weight were selected as parents of the next generation. Production of fertile eggs and obtain the highest hatchability are considered the main target for efficient and profitable chicken breeding. Furthermore, the production of fertile eggs and hatched chicks are affected by both parents and the environment[2]. Several micronutrients had inter-relationships and may affect the productive and reproductive performance of hens, especially during the last period of production[3]. Hence, the nutrient requirements for this strain should be investigated. This is the first try to investigate the effect of some nutrient on performance of Cairo B-2 broiler breeders. Homocysteine may be converted back to Meth after addition of a methyl group by folate-vitamin B_{12}-dependent Meth synthase[4]. Therefore, the experiment was designed to study the effect of different levels of Meth, FA or cyanocobalamin (B_{12}) and their interactions on productive and reproductive performance of Cairo B-2 broiler breeders from 53-64 weeks of age.

MATERIALS AND METHODS

The experimental work of the present study was carried out at the Poultry Farm, Department of Animal Production, Faculty of Agriculture, Cairo University, from February-June, 2012. The chemical analysis was conducted at the laboratories of Animal Nutrition Branch, Faculty of Agriculture, Cairo University. The effect of methionine (Meth), folic acid (FA) and vitamin B_{12} and their interactions on productive and reproductive performance of the local broiler female line (Cairo B-2) were examined and studied. The experiment was designed in a 2×2×2 factorial arrangement from 53-64 weeks of age. The nutrients, after supplementation to the female diet, were Meth (0.25 and 0.35%), FA (2.6 and 13.0 mg kg^{-1}) and B_{12} (0.03 and 0.15 mg kg^{-1}). The supplemented levels to the female and male control diets were: Meth (0.0 and 0.1%), FA (0.0 and 10.4 mg kg^{-1}) and B_{12} (0.008 and 0.128 mg kg^{-1}) (Table 1).

Table 1: Composition and calculated analysis of the basal diets[#]

Ingredients	%
Yellow corn	69.650
Soybean meal-44	20.260
Wheat bran	01.000
Lime stone	06.890
Di-calcium phosphate	01.250
Vitamin premix[1]	0.200
Mineral premix[2]	0.300
Salt	0.400
Dl-Methionine	0.050
Total	100.00
Chemical composition*	
Metabolizable energy (Kcal kg^{-1})	2800
Crude protein (%)	15.00
Crude fiber (%)	3.06
Ether extract (%)	2.84
Calcium (%)	3.00
Available phosphorus (%)	0.35
Sodium (%)	0.16
Meth (%)	0.25
Meth+cysteine (%)	0.52
Lysine (%)	0.73
Folic acid (folacin) (mg kg^{-1})	2.55
Cyanocobalamin (B_{12}) (mg kg^{-1})	0.022

[#]Chemical compositions of feedstuffs were calculated according to NIH[29]. [1,2]Each 1 kg diet contains vitamin A 11000 IU, vitamin D3 3500 IU, vitamin E 100 mg, vitamin K3 4.4 mg, vitamin B_1 6.6 mg, vitamin B_2 12 mg, vitamin B_6 4.4 mg, Vitamin B_{12} 0.022 mg, pantothenic acid 15.5 mg, nicotinic acid 50 mg, folic acid 2 mg, Biotin 0.22 mg, choline chloride 2.422 g, manganese 120 mg, zinc 110 mg, iron 44 mg, copper 9 mg, iodine 1.2 mg, selenium 0.4 mg and cobalt 0.30 mg

Seventy two females and twenty four males were randomly divided into 8 groups of 9 hens and 3 roosters, in 3 replicates each. The female control diet contained 0.25% Meth, 2.6 mg kg^{-1} FA and 0.03 mg kg^{-1} B_{12}. The experimental diets were formulated according to El-Husseiny *et al.*[3] to be isocaloric, being 2800 or 2700 kcal kg^{-1} metabolizable energy (ME) and isonitrogenous, being 15 or 13% crude protein (CP) for female or male, respectively. Hens were individually housed in 2-deck batteries of clean wire-mesh cages, with cage dimensions of 25×45 cm in open system house. Feed (in mash form) were offered in a constant amount (125 g/hen/day and 130 g/rooster/day). Water was freely offered throughout the experimental period (20 weeks), under a total of 16 h light per day regimen.

Measurements: Hen day egg production (HD) percentage was calculated every 4 weeks intervals during the experimental period (20 weeks). Eggs were collected and weighed every 4 weeks during the experimental periods. Records of egg production (EP) and egg weight (EW) were used to calculate egg mass (EM) (g/hen/day), EM and feed intake (FI) were used to calculate the amount of feed (kg) which was required to produce 1 kg of eggs per hen or to calculate feed conversion ratio (FCR)[5] during specific period. Shell thickness was determined using a dial pipe gauge. Haugh units (HU) were calculated based on the height of albumen determined by a micrometer and EW according to Eisen *et al.*[6]:

$$\text{Albumen index percentage (AI)} = \frac{\text{Height}}{\text{Diameter mean}} \times 100$$

Dry shell weighed was measured to the nearest 0.10 g:

$$\text{Egg shell percentage (ESP)} = \frac{\text{Egg shell weight}}{\text{Egg weight}} \times 100$$

Egg content weight was calculated by the difference between EW and egg shell weight:

$$\text{Egg content percentage (ECP)} = \frac{\text{Egg content weight}}{\text{Egg weight}} \times 100$$

Heamagglutination Inhibition (HI) titers against Newcastle Disease Virus (NDV) were determined according to Van der Zipp *et al.*[7]. Blood hemoglobin was measured according to Henry *et al.*[8]. Reproductive performance including fertility, hatchability and 1 day old chick's weight were calculated. Economic efficiency (EE) of either egg or chicks production were calculated from the input-output analysis which was calculated according to the price of the experimental diets, either egg or chick produced during the entire experimental period. The values of economical efficiency were calculated as the net revenue per unit of feed cost. Prices of the supplements (Meth, FA and B_{12}) were taken into consideration. The data pooled through the experiment were proceeding by General Linear Model procedures (GLM) described in SAS User's Guide[9]. The significant mean differences among treatments means were separated by Duncan's multiple range-test[10].

RESULTS

Productive performance of breeder hens: Table 2 summarizes the effect of experimental treatments on egg production % (HD), egg weight (EW), egg mass (EM) and FCR. No significant differences between either levels of methionine (Meth) or B_{12} regarding all productive performance were observed. However, the higher level of folic acid (FA) (13.0 mg kg^{-1}) was improved ($p \leq 0.05$) HD, EM and FCR. The diet contained the low level of Meth and the higher level of

Table 2: Effect of experimental treatments on productive performance[1]

Experimental treatments	Egg production (%)	Egg weight (g)	Egg mass (g/hen/day)	FCR (g g^{-1} feed egg)
Main effect				
Methionine (Meth) effect:				
0.25% (Meth1)	58.60	58.30	34.20	3.73
0.35% (Meth2)	57.00	58.20	33.30	3.87
p-value	0.19	0.92	0.35	0.21
SEM	1.28	0.60	0.84	0.10
Folic acid (FA) effect:				
2.6 mg kg^{-1} (FA1)	56.80^{b}	58.60	32.60^{b}	3.93^{a}
13.0 mg kg^{-1} (FA2)	58.90^{a}	57.90	34.90^{a}	3.67^{b}
p-value	0.001	0.46	0.03	0.03
SEM	1.11	0.59	0.78	0.09
B_{12} (B) effect:				
0.03 mg kg^{-1} (B1)	58.30	57.50	33.60	3.82
0.15 mg kg^{-1} (B2)	57.40	58.90	33.90	3.78
p-value	0.48	0.16	0.75	0.70
SEM	1.32	0.57	0.85	0.10
Meth×FA×B interactions:[2]				
T1 (Meth1+FA1+B1)	55.60^{bc}	58.80	32.70	3.87^{bc}
T2 (Meth1+FA1+B2)	53.20^{c}	58.90	31.30	4.07^{a}
T3 (Meth1+FA2+B1)	63.60^{a}	56.50	36.00	3.50^{c}
T4 (Meth1+FA2+B2)	62.10^{a}	58.80	36.60	3.47^{c}
T5 (Meth2+FA1+B1)	59.50^{ab}	56.90	31.10	4.17^{a}
T6 (Meth2+FA1+B2)	58.90^{ab}	59.60	35.10	3.60^{bc}
T7 (Meth2+FA2+B1)	54.30^{bc}	57.90	34.50	3.73^{bc}
T8 (Meth2+FA2+B2)	55.40^{bc}	58.20	32.40	3.97^{ab}
p-value	0.01	0.78	0.07	0.04
SEM	1.72	1.13	1.23	0.14

$^{a-c}$Means in same column, within each factor with different superscripts are significantly ($p \leq 0.05$) different.[1] FCR: Feed conversion ratio and the daily amount of feed consumed was 125 g/hen. [2] T1 treatment considered as control

Table 3: Effect of experimental treatments on egg quality

Experimental treatments	Egg shell thickness (mm)	Egg shell (%)	Egg contents (%)	Haugh units (%)	Albumen index (%)
Main effect					
Methionine (Meth) effect					
0.25% (Meth1)	0.389	9.60	90.40	76.30	5.20
0.35% (Meth2)	0.388	9.30	90.70	75.90	5.30
p-value	0.900	0.13	0.13	0.77	0.18
SEM	0.004	0.12	0.12	1.16	0.72
Folic acid (FA) effect					
2.6 mg kg^{-1} (FA1)	0.388	9.60	90.40	73.90^{b}	5.00^{b}
13.0 mg kg^{-1} (FA2)	0.389	9.40	90.60	78.20^{a}	5.60^{a}
p-value	0.970	0.43	0.43	0.01	0.02
SEM	0.004	0.12	0.12	1.90	0.15
B_{12} (B) effect					
0.03 mg kg^{-1} (B1)	0.389	9.40	90.60	76.60	5.30
0.15 mg kg^{-1} (B2)	0.388	9.50	90.50	75.50	5.20
p-value	0.810	0.67	0.67	0.41	0.67
SEM	0.004	0.12	0.12	1.23	0.18
Meth×FA×B_{12} interactions:[1]					
T1 (Meth1+FA1+B1)	0.384	9.40	90.60	75.90	5.20
T2 (Meth1+FA1+B2)	0.392	9.80	90.20	76.60	5.10
T3 (Meth1+FA2+B1)	0.394	9.60	90.40	76.00	5.30
T4 (Meth1+FA2+B2)	0.386	9.60	90.40	76.50	5.20
T5 (Meth2+FA1+B1)	0.383	9.30	90.70	73.20	4.80
T6 (Meth2+FA1+B2)	0.394	9.60	90.40	70.10	4.70
T7 (Meth2+FA2+B1)	0.396	9.30	90.70	81.40	5.90
T8 (Meth2+FA2+B2)	0.379	9.10	90.90	78.80	5.80
p-value	0.690	0.60	0.60	0.89	0.33
SEM	0.010	0.21	0.21	1.69	0.27

[a-b]Means in same column, within each factor with different superscripts are significantly ($p\leq0.05$) different. [1] T1 considered as control

level of FA or B_{12}, (T4: 0.25%+13.0 mg kg^{-1}+0.15 mg kg^{-1}) showed the best figures of productive performance compared to the control and other treatments.

Egg quality: The effects of experimental treatments on some either egg quality measurements or blood parameters of the hens are presented in Table 3. Neither egg quality parameters nor blood parameters were significantly affected by either levels of Meth, FA or B_{12} or their interactions, except for Haugh units and hemoglobin ($p\leq0.05$). The high level of FA improved the first, while the high level of Meth improved the later.

Reproductive performance: Effect of experimental treatments on reproductive performance is presented in Table 4. Meth levels had no significant effect on 1 day old chick weight, while low level recorded better ($p\leq0.05$) fertility (%) and hatchability (%) values compared to the higher level. The higher level of FA improved the hatchability (%), while fertility (%) and 1 day old chick weight was not significantly affected by FA level. The levels of B_{12} had no significant effect on fertility (%) and hatchability (%) values. The higher level increased 1 day old chick weight. Relative economic efficiency values were better when the low level of both Meth and B_{12} were used, while the higher level of FA recorded higher value of relative economic efficiency. The diet that contained the low level of Meth and the higher level of FA and B_{12}, (T4: 0.25% +13.0 mg kg^{-1}+0.15 mg kg^{-1}) resulted in highest ($p\leq0.05$) 1 day old chick weight value, followed by T2 which contained the low level of both Meth and FA in addition to the higher value of B_{12} (0.25%+2.6 mg kg^{-1}+ 0.15 mg kg^{-1}) compared to the control. Relative economic efficiency values showed that the diet containing the low levels Meth in addition to the high levels of both FA and B_{12} (T4) showed the highest values followed by T3 (0.25% +13.0 mg kg^{-1}+0.03 mg kg^{-1}).

DISCUSSION

The lack of information and research about amino acids and the other nutrient requirements for Egyptian local developed strains enforced the need for more efforts to investigate this issue[8]. As the first-limiting amino acid in poultry diets, Meth affects poultry production parameters such as body weight gains, feed conversion ratio and carcass quality[11].

Table 4: Effect of experimental treatments on reproductive performance and blood parameters[1]

				Blood parameters	
Experimental treatments	Fertility (%)	Hatchability (%)	Chick weight (g)	HT	Hg (g dL^{-1})
Main effect					
Methionine (Meth) effect					
0.25% (Meth1)	85.40[a]	74.00[a]	39.20	8.40	13.70[b]
0.35% (Meth2)	82.00[b]	71.90[b]	38.20	8.40	16.00[a]
p-value	0.01	0.01	0.61	0.87	0.01
SEM	1.66	1.89	0.45	0.23	0.52
Folic acid (FA) effect					
2.6 mg kg^{-1} (FA1)	84.80[a]	70.20[b]	38.70	8.30	14.20
13.0 mg kg^{-1} (FA2)	82.60[b]	75.70[a]	38.70	8.50	15.50
p-value	0.08	0.0003	0.46	0.50	0.09
SEM	1.71	1.87	0.43	0.23	0.60
B_{12} effect					
0.03 mg kg^{-1} (B1)	83.00	73.10	37.80[b]	8.50	15.00
0.15 mg kg^{-1} (B2)	84.40	72.80	39.60[a]	8.30	14.70
p-value	0.24	0.80	0.01	0.76	0.73
SEM	1.73	2.05	0.34	0.23	0.65
Meth×FA×B interactions:[2]					
T1 (Meth1+FA1+B1)	76.80[d]	64.10[d]	38.60[c]	8.70	13.50
T2 (Meth1+FA1+B2)	92.00[a]	67.80[cd]	40.10[b]	7.90	14.30
T3 (Meth1+FA2+B1)	85.40[bc]	80.10[ab]	36.60[c]	8.50	13.90
T4 (Meth1+FA2+B2)	87.40[ab]	83.80[a]	41.50[a]	8.60	13.00
T5 (Meth2+FA1+B1)	87.70[ab]	77.50[b]	38.00[d]	8.20	15.10
T6 (Meth2+FA1+B2)	82.70[bc]	71.40[c]	38.10[d]	8.30	13.70
T7 (Meth2+FA2+B1)	82.10[c]	70.60[c]	38.10[d]	8.40	17.20
T8 (Meth2+FA2+B2)	75.50[d]	68.20[cd]	38.60[c]	8.50	17.80
p-value	<0.0001	<0.0001	0.01	0.56	0.24
SEM	1.59	1.59	0.40	0.50	0.84

[a-c]Means in same column, within each factor with different superscripts are significantly ($p \leq 0.05$) different. [1]HT: Heamagglutination Inhibition titers against Newcastle Disease Virus and Hg: Hemoglobin content. [2]T1 considered as control

The previous results of productive performance attributed mainly to egg production and egg mass values because the feed intake was constant. Only FA levels had significant effect on egg mass and consequently each of feed conversion ratios. Low Meth level is satisfied to get the best productive performance of hens. For laying ducks, 0.260 and 0.410% Meth was sufficient for egg production and egg weight, respectively[12], while in duck breeders, 0.425% Meth met their needs for egg weight, egg mass, FCR, hatchability and 1 day duckling weight[13]. In Iranian commercial breeders, increasing Meth concentration than 0.20% affected negatively egg production, egg weight, egg mass and FCR without affecting the hatchability[14]. The results are in agreement with Bunchasak and Kachana[15], who reported that birds fed diet supplemented with 4 mg kg^{-1} of FA were the most efficient in converting feed into eggs. El-Husseiny *et al.*[16] observed that feeding diets supplemented with 0.01-0.02 ppm of vitamin B_{12} did not have any significant effect on egg production. Kato *et al.*[17] found that there was no effect on feed conversion due to B_{12} supplementation. Bateman *et al.*[18] reported that FCR was improved by supplemental Meth. On the other hand, Bunchasak and Kachana[15] showed the effect of feeding different levels of either FA or B_{12} on the laying performance and egg lipid composition. The study suggests that levels of either folate (0.31-10.31 mg kg^{-1} diet) or B_{12} (0, 0.01 and 0.08 ppm) in a diet based on corn and soybeans did not affect egg production of older laying hens (64-72 weeks of age). Hebert *et al.*[19] reported no significant differences in FCR due to FA supplementation. In the same line, it was revealed that dietary FA supplementation levels had no significant effect on EP and FCR[20,21]. Kato *et al.*[17] found no effect on FCR due to B_{12} supplementation. Keshavarz[20] reported that egg production was not reduced by FA and vitamin B_{12} deficiencies along with the feed intake were not significantly affected.

Supplemented diet with different levels of Meth, FA and B_{12} had no significant effects on different egg quality traits of the local broiler female line (Cairo B-2). These results indicated no additional effect on different egg quality parameters with increasing levels of Meth, FA and B_{12}. This agreed with the finding of Amaefule *et al.*[22], who reported that the supplementation of diets with Meth did not significantly influence external and internal egg quality characteristics of the layer hens. Abdalla *et al.*[23] reported that increasing dietary

Meth levels had non-significant effect on yolk, albumen and shell percentage. Jordan *et al*.[24] observed no significant effect of different levels of Meth+cysteine in the diet on the percentage of yolk and albumen of eggs from laying hens from 20-44 weeks of age. Gomes *et al*.[25] noticed that different levels of Meth+cysteine had no effect on the percentage of yolk and albumen and a linear increase for the average percentage of shell. Abdalla *et al*.[23] concluded that diet supplemented with different levels of Meth had non-significant effects on different egg quality traits of Gimmizah hen. Moreover, El-Husseiny *et al*.[16] reported that the egg quality parameters of Bovan hens represented by egg shell thickness, egg shell percentage, egg contents percentage, yolk and albumen (%), Haugh units and yolk index did not show any significant difference with either FA supplementation of corn soy based diet (at 6, 9 and 12 ppm) or vitamin B_{12} (0.01-0.02 ppm). Khalifah and Shahein[21] concluded that increasing the diet with FA up to 32 mg kg^{-1} had significant (p>0.01) affect on egg shape index, egg shell thickness and yolk percentages. Whereas, albumen height, yolk index, shell and albumen percentages had not been affected significantly by dietary FA supplementation. Similar results for egg shell thickness, percent egg content and Haugh units were observed by Hebert *et al*.[26] with 4 ppm of folate supplementation in a barley based diet. While, Balnave[27] reported that decreased Heamagglutination Inhibition (HI) titers against Newcastle Disease Virus (NDV) go parallel with increasing dietary Meth concentration. Moreover, El-Husseiny *et al*.[16] observed no significant effect of Meth and FA levels on HI titers against NDV, while a significant difference ($p\leq 0.05$) in HI titers against NDV due to B_{12} supplementation and significant effects ($p\leq 0.05$) of Meth, FA and B_{12} levels were detected on blood hemoglobin.

Balanced supply of nutrients required for normal development of the embryo[23], this conclusion supported that normal embryonic growth and development depends on a complete supply of all required nutrients within the egg. The consequences to the embryo may be lethal if the egg contains inadequate, excessive or imbalanced levels of nutrients. The results of the reproductive performance herein concluded that the low level of Meth and B_{12} is satisfied, while the high FA level gave the highest hatchability (%) compared with low level. Supplementing Gimmizah layer hen diets with different levels of Meth had insignificant effect on all reproductive performances traits[23]. Abdalla *et al*.[23] observed the highest Gimmizah baby chicks at hatching weight for the birds fed 0.451 and 0.489% Meth, without significant differences with those fed 0.380% Meth. Lien *et al*.[28] concluded that chick yields increased as dietary 2-Hydroxy-4-(methylthio) butanoic acid (HMB) supplementations were increased from 0-1 kg t^{-1}. Phospholipids are essential lipids for physiological and biochemical processes and FA supplementation increased levels of phospholipids, may be physiologically beneficial to laying hens[16]. Folate helps to produce and maintain new cells[29]. Folate is most important during rapid cell division during pregnancy[26]. Folate prevents damage to DNA[29]. Moreover, Hebert *et al*.[26] reported egg FA content is maximized when crystalline FA is supplemented to the diet at 2 mg kg^{-1} or higher. Khalifah and Shahein[21] concluded that dietary FA levels had no significant effect on fertility (%) and hatchability (%) and noticed that significant weight of baby hatched chicks had been produced with the dose of 32 mg kg^{-1} FA diet, while the other used levels had numerical increase of chick body weight. Squires and Naber[30] reported that as vitamin B_{12} level increased, hatchability (%) increased and maximum hatchability was obtained when the diet contained 8.0 µg kg^{-1} of vitamin B_{12}. The results indicated that Cairo B-2 hens fed basal diet supplemented with Meth, FA and B_{12} levels affected the values of relative economic efficiency. This result agrees with the observation of Al-Saffar and Rose[31], who reported that the levels and balance of amino acids in the diets are all important nutritional variables that affect the economic efficiency of an egg laying enterprise. Abdalla *et al*.[23] concluded that the highest economic efficiency (EE) and relative economic efficiency (REE) were recorded for layers hen fed the basal diet supplemented with 0.380% (low level) Meth compared to all other treatments levels. El-Husseiny *et al*.[16] concluded that interaction between low Meth level, FA level up to 12 mg kg^{-1} and B_{12} level up to 0.02 mg kg^{-1} gave a slight increase in REE in most treatments than diets including 0.45% Meth and generally recommended that the economic study was affected by different Meth, FA and B_{12} level.

CONCLUSION

Based on obtained results, it is concluded that the diet containing the low level of Meth and the higher level of FA and B_{12}, (T4: 0.25%+13.0 mg kg^{-1}+0.15 mg kg^{-1}) to be used to get the best productive and reproductive performance and the economic efficiency.

SIGNIFICANCE STATEMENT

This study discovers the possible influence of Meth, FA and B_{12} combination that can be beneficial for productive and reproductive performance of Cairo B-2 broiler breeders. This study will help the researchers and producers to fulfill the genetic potential of Cairo B-2 broiler breeders. Thus, a new theory on these nutrients combination and possibly other combinations, may be arrived at.

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