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Productive Performance of Bovans White Laying Hens Fed High Nutrient Density Diets Under Egyptian Summer Conditions

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ABSTRACT

A 12-week study was conducted to evaluate the productive performance of Bovans White laying hens fed high-nutrient-density diets under Egyptian summer conditions. Two hundred hens were randomly assigned to five equal dietary treatments, five replications each. Birds were kept at community cages in an open-sided laying house, provided with a daily photoperiod of 16 h and managed similarly. A control diet was formulated (as fed basis) to contain a metabolizable energy of 2880 kcal kg^{-1}, 17.40% crude protein, 4.35% Ca, 0.43% nonphytate P, 0.84% lysine, 0.41% methionine and 0.70% methionine plus cysteine. Four high nutrient density diets were also compounded to contain 102.5, 105, 107.5 and 110% of the nutrients present in the control diet, thus five mash diets were composed and used from 44-56 weeks of age. The criteria of response were feed intake, egg production, egg weight, egg mass, feed conversion, body weight change, egg components and certain traits of egg quality, nutrient digestibility and some blood plasma parameters. Feeding the high nutrient density diets exerted no positive effect on productive performance of hens, digestibility of nutrients (dry matter, organic matter, crude protein, ether extract, crude fiber, nitrogen-free extract and ash retention), some egg quality traits and most blood parameters examined but positively affected weight change, percent albumen, shell thickness, yolk index and Haugh units. It is concluded that increasing dietary nutrient density up to 110% of the recommended requirements of Bovans White laying hens does not improve their productive performance under Egyptian summer conditions.

Key words: High-nutrient-density diets, Bovans White laying hens, productive performance, egg quality, nutrient digestibility, blood parameters

INTRODUCTION

High ambient temperatures have been reported to adversely affect feed intake, egg production, egg weight and feed conversion in laying hens (Daghir, 2008). The reduction in egg production and egg weight is primarily due to reduced feed intake, resulting from exposure to high environmental temperatures. In addition to the effect of heat stress on the feed intake of chickens, protein digestibility can also be reduced (Bonnet *et al*., 1997). In this respect, Kamar *et al*. (1987) observed a decline in the retention rates of Ca, P and Mg in heat-stressed hens. Also, Wolfenson *et al*. (1987) reported that absorption of K, P and Ca was reduced due to heat stress in young turkey poults.

Since, depressed appetite is the major causative factor for the reduced performance at high temperatures, efforts were attempted in order to more accurately define the nutrient requirements of heat-stressed laying hens (Daghir, 2008). Dietary manipulations are among the nutritional strategies used to overcome the adverse effects of heat stress on the feed and energy intakes and productive performance of laying hens. Dietary fat supplementation at high temperature is well known to decrease heat increment of the feed and can improve the voluntary feed intake of heat-stressed birds (Daghir, 2008).

Under thermoneutral conditions, Wu *et al*. (2007) determined the effect of increasing both dietary energy and other nutrients (amino acids, Ca and available P) on performance, egg composition, egg solids, egg quality and profits in laying hens and found that as nutrient density increased, hens linearly adjusted feed intake to achieve similar energy intakes, egg mass linearly increased and feed conversion linearly improved. In later study, Marie *et al*. (2009) evaluated the productive performance of laying hens fed different dietary nutrient densities (ME, CP, Ca, available P, lysine, methionine and total sulphur amino acids were 5 and 10% more than those contained in the control diet) and found that feed intake decreased, nutrient intake increased and egg production, egg weight, egg mass and feed conversion were improved due to increasing nutrient density of the diet.

The aim of the present study was to evaluate the productive performance of laying hens fed high-nutrient-density diets during the second phase of egg production cycle, under Egyptian summer conditions.

MATERIALS AND METHODS

Birds and management: The present study was carried out at the Poultry Research Unit, Qalabsho Center of Agricultural Researches and Experiments belonging to Faculty of Agriculture, Mansoura University, Egypt, during the period from May to July, 2014. Ambient temperature and relative humidity, prevailing at the experimental period, ranged between 19.9 and 33.5°C and 46 and 58%, respectively. Two hundred Bovans White laying hens (44 weeks old) were randomly divided into five equal dietary treatments, each with five replications. Birds of each replicate group were housed in a community laying cage (8 pullets per cage with one feeder), the width, length and height of each cage were 80, 100 and 80 cm, respectively. The cages are placed in an open-sided laying house, supplied with an artificial light to provide a daily photoperiod of 16 h.

Experimental diets: A control diet was composed based on yellow corn, soybean meal and corn gluten meal to meet or exceed the nutrient requirements of Bovans White laying hens, as suggested by the Bovans White Management Guide (CPI., 2012). The calculated analysis of the control diet (as fed basis) was as follows: Metabolizable Energy (ME); 2880 kcal kg^{-1}, Crude Protein (CP); 17.40%, Ca; 4.35%, nonphytate P; 0.43%, lysine; 0.84%, methionine; 0.41% and methionine plus cystine; 0.70%. Four high-nutrient-density diets were also compounded to contain 102.5, 105, 107.5 and 110% of the nutrients present in the control diet. These high-nutrient-density diets were termed as HND1, HND2, HND3 and HND4, respectively. Thus, five mash experimental diets were formulated and fed to laying hens kept under Egyptian summer conditions from 44 to 56 weeks of age. Composition and chemical analyses of these experimental diets are illustrated in Table 1.

Productive performance: Data on hen-day Egg Production Rate (EPR), Daily Feed Intake (DFI), Feed Conversion Ratio (FCR), Egg Weight (EW) and Daily Egg Mass (DEM) were periodically determined on a 28-day period basis. Cumulative means of these variables were also calculated throughout the duration of the experiment. Body Weight Change (BWC) as the difference between final and initial live body weights of hens was also estimated for the whole experimental period. Mortality was also monitored daily during the whole experimental period.

Table 1: Calculated composition and chemical analyses of the experimental diets‡ fed to laying hens from 44 to 56 weeks of age

Ingredients (%)	Control	HND1	HND2	HND3	HND4
Ground yellow corn	61.65	59.15	56.68	54.48	52.82
Soybean meal (44% CP)	15.76	15.39	15.21	14.56	12.90
Corn gluten meal (60% CP)	8.00	9.30	10.40	11.83	13.85
Sunflower oil	1.60	2.80	4.00	5.09	6.00
Ground limestone	10.33	10.60	10.85	11.10	11.34
Dicalcium phosphate	1.75	1.83	1.90	1.94	2.08
Vitamin and mineral premix[1]	0.30	0.30	0.30	0.30	0.30
Common salt (NaCl)	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.08	0.08	0.08	0.08	0.07
L-Lysine-HCl	0.23	0.25	0.28	0.32	0.38
Total	100	100	100	100	100
Calculated analysis (As Fed Basis: NRC., 1994)					
Metabolizable energy (kcal kg^{-1})	2880	2952	3024	3096	3168
Crude protein (%)	17.40	17.84	18.27	18.71	19.14
Ether extract (%)	4.26	5.40	6.53	7.57	8.45
Crude fiber (%)	2.56	2.50	2.44	2.37	2.24
Calcium (%)	4.35	4.46	4.57	4.68	4.79
Nonphytate P (%)	0.43	0.44	0.45	0.46	0.47
Lysine (%)	0.84	0.86	0.88	0.90	0.92
Methionine (%)	0.41	0.42	0.43	0.44	0.45
Methionine+cystine (%)	0.70	0.72	0.74	0.75	0.78
Determined analysis (DM Basis: AOAC., 1990)					
Dry matter (%)	89.45	89.66	89.53	89.84	89.45
Crude protein (%)	19.45	19.89	20.41	20.83	21.40
Ether extract (%)	4.76	6.02	7.29	8.43	9.45
Crude fiber (%)	2.86	2.79	2.73	2.64	2.50
Ash (%)	6.95	7.24	7.53	7.67	7.87
Nitrogen-free extract (%)	65.98	64.06	62.04	60.43	58.78

‡: Diets termed as HND1 to HND4 have 102.5, 105, 107.5 and 110% of nutrient contents present in the control diet, respectively.
1: Each 3 kg of premix contained: Vit A: 12,000,000 IU, Vit D_3: 3,500,000 IU, Vit. E: 20 g, Vit. K_3: 3 g, Vit. B_1: 3 g, Vit. B_2: 8 g, Vit. B_6: 3 g, Vit. B_{12}: 15 mg, Ca pantothenate: 12 g, Niacin: 40 g, Folic acid: 1.5 g, Biotin: 50 mg, Choline chloride: 600 g, Mn: 80 g, Zn: 75 g, Fe: 40 g, Cu: 10 g, I: 2 g, Se: 0.3 g, Co: 0.25 g and $CaCo_3$ as a carrier

Egg quality measurements: An egg quality test was performed at 50 weeks of hen's age. Freshly-laid eggs (30 eggs per treatment) were randomly chosen and used to determine some parameters of egg quality. These parameters included egg weight and its relative components (shell, yolk and albumen), Egg Shape Index (ESI), Yolk Index (YI), Shell Thickness (ST), Yolk Color Score (YCS) and Haugh Units (HU). Shell Weight Per Unit Surface Area (SWUSA) was also calculated by dividing shell weight (plus adhering membranes, mg) by the Egg Surface Area (ESA, cm^2). The ESA was calculated using the following equation:

$$ESA = [(3.9782\times \text{egg weight}^{0.7056}\ (g)]$$

Digestibility trials: At 55 weeks of bird's age, five digestibility trials were conducted on laying hens to evaluate the digestion coefficients of nutrients of the experimental diets. One replicate group per treatment was fed its respective experimental diet for a three-day test period. Just after collection, the excreta were sprayed with 1% boric acid for the elimination of nitrogen loss due to a possible ammonia release. The droppings were dried in a forced-air oven at 70°C overnight. Then, they were allowed to equilibrate in moisture with atmospheric air before being weighed, finely ground and stored in plastic bags until analysis. Fecal protein fraction was separated in excreta samples and urinary organic matter was calculated. Samples of experimental diets and dried droppings were chemically analyzed according to the official methods of analysis (AOAC., 1990).

Digestibility coefficients of Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Crude Fiber (CF), Ether Extract (EE) and Nitrogen Free Extract (NFE) as well as ash retention were estimated.

Blood parameters: Blood samples were collected from the wing veins of 56 weeks old hens in heparinized tubes. Plasma was separated by centrifugation at 3000 rpm for 10 min and stored at -20°C until analysis. Concentrations of plasma total protein, albumin, total lipids, triglycerides, total cholesterol, High Density Lipoprotein Cholesterol (HDL-C), malondialdehyde (MDA), reduced glutathione (GSH), Ca and inorganic P as well as activity of plasma superoxide dismutase (SOD), alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were determined using commercial kits. Level of plasma globulin was calculated by subtracting level of plasma albumin from that of total protein.

Statistical analysis: The statistical processing of data was performed via one-way analysis of variance using the Statistical Analysis System (SAS., 2004). Differences among means of various variables were separated by Duncan's new multiple range test (Duncan, 1955) at $p \le 0.05$.

RESULTS AND DISCUSSION

Productive performance of laying hens: The obtained data revealed that Egg Production Rate (EPR), Egg Weight (EW), Daily Egg Mass (DEM), Daily Feed Intake (DFI) and Feed Conversion Ratio (FCR) were not significantly affected ($p>0.05$) by feeding the high-nutrient-density diets but Body Weight Change (BWC) of hens was positively affected ($p<0.01$) compared with that of the control group (Table 2). No deaths were observed throughout this study. It was interesting to note that though DFI of hens was not affected by the experimental diets, hens fed the HND4 diet consumed insignificantly less feed than those of the other experimental groups. The reduced DFI of that group is perhaps the main reason for the insignificant reductions in EPR and DEM but EW and FCR and were not affected. The high similarity in DFI of hens fed the control, HND1, HND2 and HND3 diets is an indication that the ambient temperatures, prevailed under the conditions of this study, were not too severe to adversely affect feed intake of hens. So, the reduced feed intake of hens fed the HND4 diet might be attributed to the increased nutrient density of the diet rather than to the effect of heat stress per se.

In harmony with the present results, Panda *et al.* (2012) evaluated the effect of various concentrations of ME with graded incremental levels of crude protein and essential amino acids

Table 2: Productive performance of laying hens fed high-nutrient-density diets from 44 to 56 weeks of age

	Experimental diets[‡]						
Parameters	Control	HND1	HND2	HND3	HND4	SEM	Significance
Egg production rate (%)	76.88	77.41	77.94	77.55	73.09	2.72	NS
Egg weight (g)	65.47	66.46	66.17	67.65	66.49	0.62	NS
Daily egg mass (g)	50.31	51.48	54.92	52.46	48.58	1.84	NS
Daily feed intake (g)	127.1	125.2	127.7	126.4	122.9	0.93	NS
Feed conversion ratio (g: g)	2.53	2.47	2.47	2.41	2.53	0.09	NS
Initial body weight (g)	1345	1336	1338	1343	1344	11.5	NS
Body weight change (g)	256[c]	453[b]	489[ab]	510[a]	520[a]	6.31	**

‡: Diets termed as HND1 to HND4 have 102.5, 105, 107.5 and 110% of nutrient contents present in the control diet, respectively, [a-c]Means in the same row having different superscripts differ significantly at $p \le 0.05$, SEM: Standard error of the means, NS: Not significant, **Significant at $p \le 0.01$

(lysine and methionine) on production performance of laying hens and found that egg production, egg weight and egg mass were not affected by increasing the dietary nutrient density to 107.5% as compared to that of the control group. In addition, Zhang and Kim (2013) investigated the effects of feeding two dietary energy levels (2700 vs. 2800) and two nutrient densities (high-nutrient-density diet containing 18.12% crude protein, 4.33% ether extract, 0.89% lysine, 0.75% methionine plus cystine, 3.57% Ca and 0.65% total P and low-nutrient-density diet containing 17.04% crude protein, 3.98% ether extract, 0.75% lysine, 0.63% methionine plus cystine, 3.45% Ca and 0.61% total P) on performance of laying hens. They found that egg production was not affected by dietary energy or nutrient density but hens fed the high-energy and high-nutrient-density diets had significantly less daily feed intake than those fed the low-energy and low-nutrient-density diets throughout the experimental period. Moreover, Rama Rao *et al*. (2014) studied the effects of feeding graded concentrations of metabolizable energy (ME; 10.04, 10.67 and 11.30 MJ kg^{-1}) and crude protein (CP; 150, 165 and 180 g kg^{-1}) on the performance of layers and found that egg production, egg weight and egg mass were unaffected by dietary variation in concentrations of ME and CP, but the feed efficiency improved and feed intake reduced with increasing concentrations of these nutrients, during the post-peak production phase. On the other hand, Wu *et al*. (2007) evaluated the performance of hens in response to feeding high nutrient density diets and found that as nutrient density increased, hens linearly adjusted feed intake to achieve similar energy intakes, egg mass linearly increased and feed conversion linearly improved. In a later study, Marie *et al*. (2009) investigated the productive performance of laying hens fed different dietary nutrient densities and found that feed intake decreased, nutrient intake increased and egg production, egg weight, egg mass and feed conversion were improved due to increasing nutrient density of the diet. Recently, De Persio *et al*. (2015) fed laying hens on diets containing 85-105% of the energy and other nutrients and found that increasing energy and nutrient density increased egg production, egg weight, egg mass, feed efficiency, energy intake and body weight.

Egg quality measurements of laying hens: Data on the effect of feeding high-nutrient-density diets on egg quality parameters of laying hens fed high-nutrient-density diets are introduced in Table 3. These data indicate that increasing nutrient density (ME, CP, EE, Ca, nonphytate P, lysine and methionine) of the diet from 100% in the control diet to 110% had no significant ($p>0.05$) effects on percent shell, percent yolk, shell weight per unit surface area, egg shape index or yolk

Table 3: Egg components and some egg quality parameters of laying hens fed high-nutrient-density diets, examined at 50 weeks of age

	Experimental diets‡						
Parameters	Control	HND1	HND2	HND3	HND4	SEM	Significance
Egg weight (g)	65.32^b	66.44^a	67.34^a	67.62^a	67.47^a	0.614	*
Shell weight (%)	12.47	12.43	12.40	12.49	12.41	0.084	NS
Yolk weight (%)	25.56	25.45	25.50	25.29	25.39	0.156	NS
Albumen weight (%)	61.26^b	62.12^a	62.07^a	62.22^a	62.19^a	0.317	*
Shell thickness (mm)	0.338^b	0.345^b	0.349^b	0.356^a	0.358^a	0.003	*
SWUSA (mg cm^{-2})	65.92	65.47	64.96	65.11	65.23	0.332	NS
Egg shape index (%)	84.75	86.01	85.71	85.76	85.91	0.470	NS
Yolk index (%)	34.81^b	35.48^a	35.85^a	36.28^a	36.38^a	0.386	*
Yolk color score	7.57	7.63	7.00	7.33	7.03	0.113	NS
Haugh units	71.38^c	74.45^b	75.87^b	77.02^a	76.80^a	0.929	**

‡: Diets termed as HND1 to HND4 have 102.5, 105, 107.5 and 110% of nutrient contents present in the control diet, respectively, a-cMeans in the same row having different superscripts differ significantly at $p\le0.05$. SEM: Standard error of the means, SWUSA: Shell weight per unit surface area, NS: Not significant, *Significant at $p\le0.05$, **Significant at $p\le0.01$

color score of laying hens. However, egg weight, percent albumen, shell thickness, yolk index and Haugh units were positively affected due to feeding the high nutrient density diets compared with those of the control group. Although average egg weight during the entire experimental period was not affected by dietary treatments (Table 2), an improvement was observed in egg weight concurrent with increases in percent albumen, yolk index, Haugh units and shell thickness (Table 3).

There is no explanation for the concurrent increase in egg weight and shell thickness for hens fed the high nutrient density diets, under the conditions of this study.

The beneficial effect of feeding the high nutrient density diets on egg weight, percent albumen, shell thickness, yolk index and Haugh units, observed in this study, is in accordance with the findings of Marie *et al*. (2009), who reported that egg weight, yolk index and Haugh units were improved due to increasing nutrient density of the diet. However, Panda *et al*. (2012) reported that increasing nutrient density up to 107.5% of that contained in the control diet had no effect on the percentages of egg components or on Haugh unit, yolk color score or shell thickness. In addition, Zhang and Kim (2013) found that hens fed high-energy and high-nutrient-density diets had no effect on egg quality traits of hens compared with those fed low-energy and low-nutrient-density diets. More recently, De Persio *et al*. (2015) observed no consistent responses in egg quality, percent yolk and percent egg solids due to feeding high-energy and high-nutrient-density diets.

Nutrient digestibility of the experimental diets: Data on the effect of feeding the high-nutrient-density diets on nutrient digestibility of the experimental diets for laying hens are presented in Table 4. Increasing nutrient density (ME, CP, EE, Ca, nonphytate P, lysine and methionine) of the diet from 100% in the control diet to 110% had no significant ($p>0.05$) effects on ash retention or digestibility of DM, OM, CP, CF, EE and NFE of laying hens. The lack of significant differences in nutrient digestibility of laying hens in response to feeding high-nutrient-density diets, under the conditions of the present study, coincides with the observed similarity in their achieved productive performance (Table 2), since dietary treatments had no effect on either feed intake or feed conversion ratio.

In harmony with the present results, Danicke *et al*. (2000) examined the effects of added soy oil (0, 3.5, 7, 10.5 and 14%) and dietary protein level (13.2 and 16.3%) on precaecal nutrient digestibility in laying hens and found that digestibility of crude protein and amino acids were not affected by either protein content of the diet or by soy oil supplementation. The present results harmonize also with the findings obtained by Han and Thacker (2011), who evaluated the effects of feeding two dietary energy levels (11.81 and 11.39 MJ kg^{-1} of ME referred to as high and

Table 4: Nutrient digestibility of the experimental diets for 55 weeks old laying hens fed diets containing high nutrient densities

	Experimental diets‡						
Parameters (%)	Control	HND1	HND2	HND3	HND4	SEM	Significance
Dry matter	69.21	69.31	69.12	69.20	69.06	0.171	NS
Organic matter	76.08	76.28	76.36	76.01	76.13	0.316	NS
Crude protein	81.82	81.82	81.32	81.51	82.03	0.261	NS
Crude fiber	30.63	30.55	30.87	30.47	30.68	0.233	NS
Ether extract	79.79	79.55	79.75	79.70	79.53	0.132	NS
Nitrogen-free extract	62.68	62.81	62.70	63.30	62.64	0.347	NS
Ash retention	32.08	32.28	32.36	32.01	32.13	0.316	NS

‡: Diets termed as HND1 to HND4 have 102.5, 105, 107.5 and 110% of nutrient contents present in the control diet, respectively. SEM: Standard error of the means, NS: Not significant

moderate energy levels, respectively) on nutrient digestibility in laying hens. They found that dietary energy level had no significant effect on digestibility of organic matter, crude protein, ether extract or on the digestibility of essential amino acids (arginine, histidine, leucine, isoleucine, lysine, methionine, cysteine, phenylalanine, threonine, valine and glycine). In partial agreement with the present results, Awad *et al.* (2013) investigated the effect of different dietary levels of metabolizable energy (2750, 2850 and 2950 kcal ME kg^{-1}) and crude protein (15, 17 or 19%) on nutrient digestibility in laying ducks. They reported that dietary energy level did not significantly affect digestibility of crude protein, crude fiber or ether extract but digestibility coefficients of dry matter, organic matter and nitrogen-free extract were significantly higher for laying ducks fed the diet containing 2850 kcal ME kg^{-1} than those fed the diets containing either 2750 or 2950 kcal ME kg^{-1}. They also observed that digestibility coefficients of dry matter, organic matter and nitrogen-free extract were not affected by dietary protein level, however, increasing dietary protein level significantly increased the digestibility of crude protein but decreased ether extract digestibility.

In contrast to the present results, Jalal *et al.* (2006) reported that laying hens fed the diet with 2900 kcal of ME kg^{-1} had significantly greater ME digestibility compared with those fed the diets containing 2800 or 2580 kcal of ME kg^{-1}, respectively. In addition, Novak *et al.* (2006) evaluated the effect of dietary protein level and total sulfur amino acids (TSAA) to lysine ratio on egg production parameters in Hy-Line W-98 hens and found that protein retention was generally improved due to feeding low-protein diets and by increasing the TSAA to lysine from low to high. With broiler breeder hens, Enting *et al.* (2007) studied the effects of low-density diets on nutrient digestibility at 22 weeks of age and found that digestibility coefficients of organic matter, crude protein, crude fat and nitrogen-free extract and apparent ME contents were lower when nutrient density of the diets decreased.

Inconsistent results in the scientific literature on the nutrient digestibility in laying hens due to feeding diets of varying nutrient concentration could be related to many factors, such as heat tress conditions (constant high temperatures vs. cyclic temperatures, acute heat stress vs. chronic heat stress, relative humidity associated with high ambient temperature), type of nutrient concerned, the extent to which dietary nutrients are increased or decreased, physiological status of laying hens (early laying period, peak of egg production, late laying period or post-molt laying hens), diet form and composition, plane of nutrition (or level of feed intake), duration of study, species of laying bird and strain of laying hens.

Blood parameters of laying hens: Data on the effect of feeding high-nutrient-density diets on blood plasma parameters of 56 weeks old Bovans White laying hens are given in Table 5. Analysis of variance of these data showed that dietary treatments had no significant effects ($p>0.05$) on plasma levels of total protein, albumin, globulin, total lipids, Ca, inorganic P, total cholesterol or activity of ALT and AST in blood plasma. On the other hand, hens fed the HND3 and HND4 diets (containing 107.5 and 110% of the nutrients present in the control diet) exhibited significantly ($p<0.01$) higher plasma concentrations of MDA, GSH and triglycerides compared with the control group but plasma levels of these three constituents of laying hens fed the HND1 and HND2 were not significantly different from those of the control hens (Table 5). It is established that MDA is formed as an end product of lipid peroxidation and therefore, the extent to which lipid peroxidation occurs by reactive oxygen species can be monitored by the level of MDA. In the present study, feeding the experimental diets produced significant fluctuations ($p<0.01$), with no clear-cut trend,

Table 5: Blood parameters of 56 weeks old laying hens fed high-nutrient-density diets

	Experimental diets‡						
Parameters	Control	HND1	HND2	HND3	HND4	SEM	Significance
Total protein (g dL^{-1})	5.04	4.85	4.93	4.81	5.01	0.126	NS
Albumin (g dL^{-1})	2.47	2.35	2.43	2.34	2.47	0.057	NS
Globulin (g dL^{-1})	2.57	2.50	2.50	2.47	2.55	0.075	NS
Total lipids (g dL^{-1})	6.95	7.00	6.94	9.13	9.35	0.136	NS
Ca (mg dL^{-1})	11.47	11.42	11.65	11.56	11.77	0.337	NS
Inorganic P (mg dL^{-1})	6.59	6.63	6.46	6.56	6.52	0.232	NS
AST (IU L^{-1})	22.73	23.37	22.67	22.75	22.88	0.332	NS
ALT (IU L^{-1})	11.70	11.29	11.53	11.41	11.57	0.339	NS
SOD (U mL^{-1})	147.5^{c}	175.5^{a}	164.8^{b}	141.5^{d}	138.1^{e}	0.192	**
MDA (μmol mL^{-1})	9.31^{b}	8.98^{b}	9.15^{b}	11.18^{a}	11.22^{a}	0.170	**
GSH (μmol mL^{-1})	14.62^{b}	13.95^{b}	14.31^{b}	18.35^{a}	18.44^{a}	0.340	**
Triglycerides (mg dL^{-1})	309.3^{b}	299.2^{b}	304.7^{b}	365.2^{a}	366.7^{a}	5.100	**
Cholesterol (mg dL^{-1})	321.3	321.3	322.0	324.5	325.6	1.243	NS
HDL-C (mg dL^{-1})	25.39^{a}	25.32^{a}	24.96^{ab}	24.15^{b}	23.08^{c}	0.302	**

‡: Diets termed as HND1 to HND4 have 102.5, 105, 107.5 and 110% of nutrient contents present in the control diet, respectively, [a-e]Means in the same row having different superscripts differ significantly at $p \leq 0.05$, NS: Not significant, **Significant at $p \leq 0.01$, SEM: Standard error of the means, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, SOD: Superoxide dismutase, MDA: Malondialdehyde, GSH: Glutathione, HDL-C: High density lipoprotein cholesteral

in plasma SOD activity whereas plasma concentration of HDL-C was significantly decreased ($p<0.01$) in response to feeding the HND3 and HND4 diets compared with their control counterparts (Table 5). The lower activity of SOD coincided with higher concentrations of GSH, MDA and triglycerides in plasma of hens fed the HND3 and HND4 diets might be an indication to enhanced lipid peroxidation by reactive oxygen species due to lower activity of the antioxidant enzymatic activity in the plasma of laying hens.

The observed insignificant differences in most blood parameters of Bovans White laying hens, examined herein, in response to feeding the high-nutrient-density diets agree with the results of Rabie *et al*. (2010), who investigated the combined effects of feeding starter and grower diets having different metabolizable energy contents (2700, 2900 and 3100 kcal kg^{-1} diet) on blood parameters of broiler chicks, and found that dietary energy level had no significant effect on blood parameters investigated. Working with Japanese quail, Rabie *et al*. (2015) reported that blood plasma levels of total protein, total lipids, total cholesterol and activity of AST and ALT were not affected by dietary protein level (20, 22 and 24%).

In contrast to the present results, Zhang and Kim (2013) evaluated the effects of feeding the laying hens two dietary energy levels (2700 vs. 2800) and two nutrient densities (HND diet: contained 18.12% CP, 4.33% ether extract, 0.89% lysine, 0.75% methionine plus cystine, 3.57% Ca and 0.65% total P versus LND diet: contained 17.04% CP, 3.98% ether extract, 0.75% lysine, 0.63% methionine plus cystine, 3.45% Ca and 0.61% total P) on serum cholesterol concentrations and found that serum HDL cholesterol concentration increased significantly by feeding high-energy and high-nutrient-density diets. In addition, Roland *et al*. (1996) investigated the influence of dietary calcium level and ambient temperature on performance of first-cycle commercial Leghorns and found that increasing dietary Ca level increased ionic plasma Ca in laying hens.

CONCLUSION

It is concluded that increasing dietary nutrient density up to 110% of the recommended requirements of Bovans White laying hens does not improve their productive performance under Egyptian summer conditions.

REFERENCES

AOAC., 1990. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists, Washington, DC., USA., Pages: 684.

Awad, A.L., K. Elkloub, M. El Moustafa, A.I.A. Ghonim and A.R. Nehad, 2013. Comparative study for different levels of energy and protein in local duck breeds rations during laying period. Egypt. Poult. Sci., 33: 825-847.

Bonnet, S., P.A. Geraert, M. Lessire, B. Carre and S. Guillaumin, 1997. Effect of high ambient temperature on feed digestibility in broilers. J. Poult. Sci., 76: 857-863.

CPI., 2012. Bovans white management guide, North American Edition. Centurion Poultry Inc., USA. http://www.centurionpoultry.com/.

Daghir, N.J., 2008. Poultry Production in Hot Climates. 2nd Edn., CAB International, Wallingford, Oxford, UK., ISBN-13: 9781845934170, Pages: 387.

Danicke, S., I. Halle, H. Jeroch, W. Bottcher, P. Ahrens, R. Zachmann and S. Gotze, 2000. Effect of soy oil supplementation and protein level in laying hen diets on praecaecal nutrient digestibility, performance, reproductive performance, fatty acid composition of yolk fat and on other egg quality parameters. Eur. J. Lipid Sci. Technol., 102: 218-232.

De Persio, S., P.L. Utterback, C.W. Utterback, S.J. Rochell and N. O'Sullivan *et al*., 2015. Effects of feeding diets varying in energy and nutrient density to Hy-Line W-36 laying hens on production performance and economics. Poult. Sci., 94: 195-206.

Duncan, D.B., 1955. Multiple range and multiple *F* tests. Biometrics, 11: 1-42.

Enting, H., A. Veldman, M.W.A. Verstegen and P.J. van der Aar, 2007. The effect of low-density diets on broiler breeder development and nutrient digestibility during the rearing period. Poult. Sci., 86: 720-726.

Han, Y.K. and P.A. Thacker, 2011. Influence of energy level and glycine supplementation on performance, nutrient digestibility and egg quality in laying hens. Asian-Aust. J. Anim. Sci., 24: 1447-1455.

Jalal, M.A., S.E. Scheideler and D. Marx, 2006. Effect of bird cage space and dietary metabolizable energy level on production parameters in laying hens. Poult. Sci., 85: 306-311.

Kamar, G.A.R., M.I. El-Kotoury, M.S. Samy and E.M.A. El-Masry, 1987. Effect of different environmental conditions on the pathways of calcium, phosphorus and magnesium in Fayoumi layers. Assiut Vet. Med. J. Egypt, 16: 285-301.

Marie, Y.A., M.A. Ibrahim, M.A. Mahmoud and H.A. Abou-Khashaba, 2009. Influence of nutrient density on productive and reproductive performance of some local laying hen strains. Egypt. Poult. Sci., 29: 527-564.

NRC., 1994. Nutrient Requirements of Poultry. 9th Edn., National Academy Press, Washington, DC., USA., ISBN-13: 9780309048927, Pages: 155.

Novak, C., H.M. Yakout and S.E. Scheideler, 2006. The effect of dietary protein level and total sulfur amino acid:Lysine ratio on egg production parameters and egg yield in Hy Line W-98 hens. Poult. Sci., 85: 2195-2206.

Panda, A.K., S.V.R. Rao, M.V.L.N. Raju, M. Niranjan and M.R. Reddy, 2012. Effect of nutrient density on production performance, egg quality and humoral immune response of brown laying (Dahlem Red) hens in the tropics. Trop. Anim. Health Prod., 44: 293-299.

Rabie, M.H., F.S.A. Ismail and S.K. Sherif, 2010. Effect of dietary energy level with probiotic and enzyme addition on performance, nutrient digestibility and carcass traits of broilers. Egypt. Poult. Sci. J., 30: 179-201.

Rabie, M.H. and H.M.A. Abo El-Maaty, 2015. Growth performance of Japanese quail as affected by dietary protein level and enzyme supplementation. Asian J. Anim. Vet. Adv., 10: 74-85.

Rama Rao, S.V., V. Ravindran, M.V.L.N. Raju, T. Srilatha and A.K. Panda, 2014. Effect of different concentrations of metabolisable energy and protein on performance of White Leghorn layers in a tropical climate. Br. Poult. Sci., 55: 532-539.

Roland, D.A.Sr., M.M. Bryant, R.H.W. Abon and J. Self, 1996. Influence of calcium and environmental temperature on performance of first-cycle (Phase 1) commercial Leghorns. Poult. Sci., 75: 62-68.

SAS., 2004. SAS® User's Guide. 10th Edn., SAS Institute Inc., USA.

Wolfenson, D., D. Sklan, Y. Graber, O. Kedar, I. Bengal and S. Hurwitz, 1987. Absorption of protein, fatty acids and minerals in young turkeys under heat and cold stress. Br. Poult. Sci., 28: 739-742.

Wu, G., M.M. Bryant, P. Gunawardana and D.A. Roland Sr., 2007. Effect of nutrient density on performance, egg components, egg solids, egg quality and profits in eight commercial Leghorn strains during phase one. Poult. Sci., 86: 691-697.

Zhang, Z.F. and I.H. Kim, 2013. Effects of probiotic supplementation in different energy and nutrient density diets on performance, egg quality, excreta microflora, excreta noxious gas emission and serum cholesterol concentrations in laying hens. J. Anim. Sci., 91: 4781-4787.