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EFFECT OF DIETARY DIFFERENT LEVELS OF ENERGY AND PROTEIN FORTIFIED WITH METHIONINE ON PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF SINAI LAYING HENS

A. A. Alderey and S. A. Dorgham

Anim. Prod. Res. Inst., Agric. Res. Center, Minis. of Agric., Dokki, Giza Cairo, Egypt.

Corresponding author: A. A. Alderey Email:aeldorei2010@arc.sci.eg

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ABSTRACT: Crude protein and metabolizable energy levels are the most important nutritional measures to evaluate poultry diets. The experiment was performed with 144 Sinai laying hens (25 wk.) divided into 6 groups (two energy levels; 2700 and 2850 kcal/kg diet) and three protein levels: 14, 16 and 18 %. The essential amino acid methionine was added to both diets containing 14 and 16% CP to reach the level of sulfur amino acids equal to that in the 18% protein diet in a factorial experimental design (2X3). The results could be summarized as follows: increasing both energy or protein levels displayed highly significant improvements ($P \leq 0.01$) in final body weight (FBW), change body weight (CBW), feed conversion ratio (FCR), egg number (EN), egg weight (EW), daily egg mass (EM) and hen-day egg production rate (HDEP), while low-energy diets caused significant increase ($P \leq 0.01$) in daily intake of feed (DFI), protein (DPI), energy (DEI); protein efficiency ratio (PER) and metabolizable energy efficiency ratio (MEE). The increase in protein levels led to a significant increase ($P \leq 0.01$) in DPI and PER. Birds fed diets with 16% or 18% protein at high-energy level attained the highest FBW, CBW, EN, EW, EM and HDEP values and no significant variations were observed among them. Egg quality criteria, fertility and hatchability were not significantly affected by studied factors. Increasing energy to 2850 kcal/kg resulted in a highly significant increase ($P \leq 0.01$) in cholesterol, and increasing protein level to 18% exhibited an increase in AST and ALT levels in the blood compared to other treatments. It could be concluded that fortification with methionine was not able to effectively compensate for the low-CP diet.

From an economic perspective, it can be suggested that 16% CP diet fortified with methionine and 2850 kcal/kg is optimal for Sinai laying hens in order to maximize profitability during the study period from 25– 40 week.

Keywords: Dietary energy, crude protein, methionine, Sinai laying hens, productive, reproductive performance

INTRODUCTION

Protein is the most expensive vital element. Therefore, reducing the level of protein in poultry diets is the first step to reducing the cost of feeding and to decrease the nitrogen emissions in the environment. Additionally, research on livestock and poultry has demonstrated that supplementing a low-protein diets with specific synthetic amino acids can enhance protein digestibility, efficiently lower nitrogen emissions, (Graciene *et al*., 2016) and decrease, feed costs (Wu *et al*., 2015). In addition to reducing the amount of soybean meal used, low-protein diets for poultry may be an effective way to enhance animal welfare, improve intestinal health (less digestive disorders and improved health status), and lower environmental emissions (fewer N-excretion and ammonia emissions, Qaisrani *et al*., 2015; Apajalahti and Vienola, 2016).

Certain crystalline amino acids are necessary to sustain the supply of the limiting amino acids and the bird's performance when the CP content in the diet is reduced. (Ullrich *et al*., 2018; Alfonso-Avila *et al*., 2019; Lemme *et al*., 2019). It is crucial to maintain the supply and balance of amino acids in poultry diets in accordance with the needs of the birds in order to successfully lower crude protein levels while preserving performance. Free amino acids should therefore be included in the diet in sufficient amounts (Harn *et al*., 2021).

According to Alagawany *et al*. (2015), it can currently formulate diets for poultry that contain a small amount of extra amino acid and nonprotein nitrogen. However, Zeweil *et al*. (2011) stated that we are unable to create diets that include the optimal levels of essential amino acids while having extremely low crude protein levels. Nonetheless, it is easy to minimize the supply of crude protein by 15-20% if the expense of taking supplements containing synthetic amino acids is reasonable and appropriate (Aarnink *et al*. 1993).

Lipids offer a concentrated energy source that meets the needs of poultry, resulting in energy a costly component of their diets. Thus, in poultry diets, energy is the most expensive component (Murugesa *et al*., 2017). Feed costs account for more than 60% of the total costs associated with producing swine and poultry, with energy being the most expensive component at 70% of feed costs (Noblet and van Milgen, 2013). It's critical to determine the feed ingredients' available energy content with accuracy.

Several authors note that commercial laying hens adjust their feed consumption in response to the amount of energy in their diet. Thus, laying hens are able to control their feed intake according to their energy needs. The hens take in less feed when their dietary energy levels increase. Conversely, if the diet is too low, layers are not likely to increase their feed intake to compensate for a decrease in energy content (Leeson and Summers, 2009).

This study is an attempt to determine the extent to which it is possible to reduce the protein level that fortifies methionine with different energy levels in accordance with the ideal protein concept in an effort to lower N excretion and enhance the health of Sinai laying hen diets without compromising the production performance of the hens, which is similar to those fed on high-CP diets.

MATERIALS AND METHODS

An experiment was carried out at Gimmizah Research Station, Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture, Egypt.

Birds, diets, and experimental design:

The experimental birds were raised in floor pens until they were 24 weeks old. After that, they were placed in individual battery cages and given a week to acclimate to their new environment. During the acclimation and experimental periods, birds were fed the experimental diets. In a factorial experimental design (2X3), the birds were randomly assigned to six treatment groups with approximately the same body weights. Experimental diets were offered in a form mash and consisted of the two metabolizable energy (ME) levels 2700 and 2850 kcal/kg. Additionally, there are three dietary protein levels: 18% for high CP, 16% for medium CP and 14% for low CP. Methionine is added to the CP at rates of 14 and 16%, so that the diet is equivalent to 18% protein of its SAA content present in the diet, as shown in Table (1). During the experimental period (25-40 wk.), the birds had *adlibitum* access to feed and fresh water. Throughout the study, a lighting schedule of 16 h of light and 8 h of darkness was maintained.

Data collection:

The BW of each hen was recorded at the beginning and end of the study. Body weight change was determined by subtracting the initial weight from the final body weight for each hen using a digital scale listed in grams. Daily feed intake (DFI), egg weight (EW) and egg number (EN) were recorded. Feed conversion ratio (FCR) was calculated according to formula; grams of feed consumed for every gram of egg mass (EM) produced. The hen's egg production rate was calculated by dividing the (EN) produced during the days of the experimental period by the average number of birds during the same period and multiplying by 100.

Egg quality measurements:

To determine the measurements of egg quality, thirty eggs were randomly collected for each treatment group at the ages of 33, 34 and 35 weeks. After collection, the measurement was performed in three hours. Using a steel vernier caliper, the length and width of the egg were measured to compute the egg shape index. Eggs were weighted then broken and a micrometer screw gauge was used to determine eggshell thickness by averaging three points on the egg (air cell, equator and sharp edge), as well as albumen height, yolk height and yolk diameter. Yolk color was estimated by using a rough fan, while the Haugh unit was computed according to Larbier and Leclercq (1994) as follows: Haugh units = $100 \log (H + 7.57 - 1.7Ew^{0.37})$ where H = albumen height (mm) and EW = egg weight (g). The formula for calculating yolk index was yolk height × 100 divided by yolk diameter. Using a sensitive weighting balance, the weights of the egg's yolk, albumen, and shell were divided by the egg weight to get percentages of each component. The weight of the entire egg was subtracted from the weight of the egg yolk and shell to get the albumen weight. The formula for calculating egg-specific gravity was based on Harms *et al*. (1990). Egg surface area (ESA) = $3.9782EW^{0.7056}$ (Carter, 1974, 1975).

Fertility and hatchability:

At 36, 37 and 38 weeks of age, the percentages of hatchability and fertility were calculated. Twenty cockerels fed a diet containing 16% CP and a 2750 kcal/kg diet (same strain and age) provided a constant volume of diluted semen (1:1) for artificial insemination twice a week in all the hens in each treatment group. A total of 300 eggs were collected from each of the three hatches during a period of seven days, and they were held at 17 °C and 70% relative humidity in order to be set up for an incubator. The eggs were placed in the incubator and then eggs were candled on day eighteen of incubation to determine fertility. Then transfer the eggs to the hatchery. After hatching, the chicks have been collected and weighed.

Blood sample:

Three hens were randomly chosen at the end of experimental period from each treatment. A blood sample was extracted from the left ventricular vein using a 5-mL heparinized syringe. An ice-cold tube was used to draw the blood sample. After a 10-minute centrifugation at 4000 for 10 minutes at 4 °C, plasma samples were obtained and stored at − 20 °C until they were analyzed using commercial kits to measure plasma concentrations of total protein, albumin, glucose, cholesterol and activity transaminases enzymes (AST and ALT). The level of plasma globulin was calculated as plasma total protein minus albumin, ignoring the amount of blood plasma from fibrinogen.

Economic efficiency:

To assess economic efficiency, costs and returns were considered. The cost of the feed was the only expense included in the study; all other costs, including labor, medication, housing, water, energy, etc., were assumed to be the same for each treatment. The cost of feeding was estimated using the quantity of materials in each experimental diet and their price at the time of the experiment. Net revenues were determined by deducting expenditures from total revenues, whereas revenue was determined by selling the fertile eggs produced during the trial period and the change in body weight. Economic efficiency was calculated as follows: Economic efficiency = net revenue / total feed cost * 100.

Data analysis:

Three protein levels (14, 16 and 18%) and two dietary ME levels (2700 and 2850 kcal/kg) were arranged in a factorial arrangement (2 x 3) in a completely randomized design. Using the SPSS computer program, two-way analysis of variance was used to analysis the data in accordance with the General Liner Model (GLM) approach (**SPSS, 2011**). The mathematical model utilized was as follows: $Y_{ijk} = \mu + ME_i + P_j + (ME\ P)_{ij} + e_{ijk}$.

where, Yijk = an observation. μ stands for overall mean. Pj = the protein level effect (j = 1, 2 and 3), MEi = the metabolizable energy effect (i = 1, 2), (MEP) ij = (ME x P) ij protein levels and energy have an interaction effect and e_{ijk} = the random residual error. The significant differences between the means of several variables were found using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION:

Productive performance:

The effects of dietary energy and protein levels and their interaction on FBW, CBW, DFI, DPI and DEI, as well as PER and MEE of Sinai laying hens, are displayed in Tables 2 and 3. The results demonstrated that the increasing energy level up to 2850 Kcal/kg caused highly significant improvements ($P \leq 0.01$) in FBW, CBW and FCR. In contrast, feeding birds 2700 Kcal/kg diet significantly increased ($P \leq 0.01$) their DFI, DPI, DEI, PER and MEE compared to feeding 2850 Kcal/kg diet. This is logic because hens would attempt to maintain amino acid requirements by increasing their feed, which will raise their energy consumption overall.

The low-protein diets fortified-methionine, 14 and 16%, did not significantly differ from the 18 % protein diet terms of BW and CBW; however, DPI, PER and FCR significantly improved with high-protein levels. As well, no significant differences were observed between birds fed diets containing 14 or 16% protein in DFI and DEI.

With regard to the interactions between energy and protein levels, it is evident that all the previously mentioned traits were significantly impacted by either energy or protein level. However, the FBW and CBW of birds fed 16 % protein fortified with methionine and those fed 18% protein were similar with high or low energy content. On the other hand, as compared to their counterparts with high energy, the birds fed low-protein diets fortified with methionine at a low energy level displayed the greatest DPI value. Birds fed diet containing 18% protein content achieved the highest PER value with high energy, while the worst value of PER was scored when feeding hens diet containing 14% protein with high energy. The highest values of MEE were scored in birds fed diets containing low energy levels with any protein level compared to their counterparts with high energy levels. The best values of FCR were obtained with high energy in response to feeding 18% protein level; however, there were insignificant differences between birds receiving 14% protein fortified with methionine at a high energy level and those fed 18% protein level with low energy levels. Birds fed 14 % diet under low-energy level scored the worst value of FCR compared to other treatments. Our findings are consistent with those of Alderey (2020), who observed that raising the energy to 2850 kcal/kg diet significantly improved FBW, BWC and FCR of Montzah hens. It was demonstrated that, at 2850 kcal/kg, hens receiving diets containing 14 or 16% CP fortified with methionine were equal to those receiving diets containing 18% CP in terms of FBW. Similarly, Noetzold *et al*. (2023) indicated that hens fed high ME diets have a tendency to weigh 15 g more than those fed low ME diets. Additionally, birds provided with low levels of dietary energy tended to consume more feed in order to meet their energy needs. (Lu *et al*., 2021). Nofal *et al*. (2018) noted that hens provided diet containing 2800 kcal ME/kg showed significant improvements in changes in BW, FBW and FCR than those fed diet containing 2600 kcal ME/kg. Moreover, birds fed low-energy diet consumed significantly more feed than birds fed high-energy diet. This could be explained by the fact that lowering dietary ME levels reduces the amount of energy available for fat deposition, which in turn reduces body weight increase. Some studies noticed a similar pattern when they observed that feeding laying hens more fat or energy reduced their FI and improved their FCR (Wu *et al*., 2005). It's may be due to that the birds were feeding to cover their requirements for energy, which is why the higher metabolizable energy content in the diet resulted in a lower FI. Consequentially, when their energy requirements were satisfied, the birds stopped feeding, allowing them to regulate their FI in line with the feed's energy content (Fonseca *et al*., 2021). Similar decreases in FI due to increased dietary energy have been observed in other research in laying hens (Kang *et al*., 2018 and Awad *et al*., 2022). On other hand, Hassan *et al*. (2020) illustrated that hens provided a diet containing 2800 kcal ME/kg showed neither BW nor EW significantly differed between the two energy levels.

Our results concur with Alagawany *et al*. (2020), who revealed that hens fed 18 % CP a diet had the best FBW and CBW compared to those fed low-CP diet. Alderey (2020) found that in low-protein diets, the amount of soybean meal has been reduced and consequently, the lysine level is low. This has disrupted the essential amino acid balance, particularly total sulfur amino acids and lysine, which are the two first-limiting amino acids. Therefore, increasing the amount of methionine in these diets is necessary to achieve a constant level of SAA. Nevertheless, it seems that this strain cannot raise feed intake to the level necessary to make up for low dietary ME and CP levels, where it satisfies requirements for energy, protein and/ or other nutrients (amino acids) in order to perform its optimum level. In comparison to different CP levels (15, 15.5, 17.51 %), Yakout (2010) reported that reducing protein level to 13% supplementation with Met, Thr, Lys and Trp significantly decreased BW and protein intake. Moreover, Kumari *et al*. (2016) revealed that a hen's body weight improved as its protein intake increased. As reported by Van Emous *et al*. (2015), birds provided low-CP content consumed more feed than birds fed high-CP content, which may have been caused by an appetite for amino acids.

In partial agreement with Kim and kang (2022) observed that Hy-Line Brown laying hens' performance (30-50 wk.) was unaffected by protein levels (16.5 and 14.5%). However, the increasing energy level up to 2800 kcal/kg exhibited a decrease in FI but EW and FCR were improved. However, Tenesa *et al*. (2016) showed that hens fed low-protein diets (17 and 16.5%) supplemented with threonine, lysine, and methionine did not significantly differ in terms of live body weight from those fed 17.5% CP. Yakout (2000) demonstrated that laying hens given various levels of CP showed insignificant differences in BW. Hens will attempt to maintain their requirements for amino acids by consuming more feed, which will increase their energy intake overall. The higher crude protein requirements for maintenance in hens kept on a free-range environment are probably due to their increased feed intake to keep up with their higher energy expenditure (Leenstra *et al*., 2014; Brainer *et al*., 2015).

Hen productive performance:

The findings demonstrated a highly significant ($P \leq 0.01$) increase in EN, EW, EM, and HDEP in response to increasing dietary energy to 2850 kcal/kg, as shown in Table 4. The same trend was observed, the previous traits were significantly increased ($P \leq 0.01$) in response to raising protein content from 14% to 18%. In spite of all of the aforementioned characteristics being similar in birds fed 16 or 18 % protein levels, no improvements in any of the aforementioned attributes were observed in birds fed 14 % protein that were fortified with methionine.

As for the interaction between dietary protein and metabolizable energy levels, results revealed that there were significant differences among treatments affected by protein and metabolizable energy levels, where birds receiving a diet containing 14% protein fortified with methionine at the low-energy level scored the lowest values of EN, EW, daily EM and HDEP compared to other treatments. Conversely, birds fed a high-energy level with any level of protein achieved the greatest values of the EN, EW, daily EM and HDEP compared to their counterparts at a low-energy level, with no significant variations between them being found. Regarding the EN, daily EM and HDEP, there are no significant differences between birds given a 16% protein content fortified with methionine and those fed on 18% protein content, irrespective of energy levels.

Hens received diets containing 2850 kcal/kg ME, 14% fortified with methionine, produced daily EM equal to those fed protein content (16 or 18%) at low energy levels. Our results corroborated with those of Alderey and El-weshahy (2019), who indicated that birds fed diets containing 2850 kcal/kg showed significant improvements in EW, EN, HDEP and daily EM when compared to those fed a diet of 2700 kcal/kg. Similarly, Costa *et al*. (2009) reported that when ME levels increased from 2650 to 2950 Kcal/kg diets, there was an important increase in FI, EP, EM, and FCR / EM and / dozen eggs but the egg weight didn't change. The metabolizable energy levels had a quadratic impact on EP, EM and FCR / mass of an egg and / dozen eggs. Furthermore, incorporating fat into the diet might result in increases in energy levels and improvements to FCR and EW. (Wu *et al*., 2005). In the same trend Hassan *et al*. (2020) found that hens received a diet containing 2800 kcal ME/kg exhibited significantly higher EM and EP rate, as well as significantly superior feed efficiency, than those fed a diet containing 2600 kcal ME/kg.

Contrary to the our findings, another study on Hy-Line brown pullets by Xin *et al*. (2022) found no differences in the dietary treatments for hens fed metabolizable energy at 2800 or 2700 kcal/kg and protein levels at 16.5 or 15% CP. The absence of an energy effect may be due to the small variation in protein and energy levels used in each of them. According to a different study by Kim and Kang (2022) who found that the laying performance was unaffected by varying dietary protein levels (16.5 or 14.5% CP) during 30 to 50 weeks of age. When diets' energy levels were increased from 2700 to 2800, EW and FCR were improved, but FI declined. According to Sharif *et al*. (2020), dietary energy levels of 2750 or 2800 kcal/kg did not affect on EP, EW, egg quality measures and blood metabolites. The small variation between the two energy levels that were used could be the cause of this lack of impact on energy levels.

The current study displayed a significant increase in EN, EW, daily EM, and HDEP in response to increasing protein concentration from 14 to 16%. These findings agree with the results of Alderey and El-weshahy (2019), who noticed that increasing the protein content from 14 to 16% resulted in a significant increase in EM, EW, HDEP and EN. Silva Viana (2017) illustrated that a decline in dietary CP caused reductions in EW, EM and layer productivity. Hens that received a diet containing 170 g of CP/kg had higher EW and mass than those fed on a 150 and 130 g CP/kg diet. Furthermore, the FCR / kg of eggs was impaired and FI was lowered in response to diets containing 130 g CP/kg. Similarly, Silva *et al*. (2010) indicated that lowering protein level to 120 g/kg caused a gradual reduction in EW and EM values, even meeting the needs for all essential amino acid in the layer. In a study conducted by Bagheri *et al*. (2020) found that increases in dietary energy and nutrient density increases EP, EW, EM, EI, FCR and body weight gain.

According to Novak *et al*. (2006), interactions between amino acids may also be responsible for the decrease in EP, potentially as a result of consuming excessive amounts of essential amino acids from low-protein diets. However, essential amino acids may have a restricted influence due to their conversion to nonessential amino acids, which are found in small quantities in low-amino-low-protein diets. Additionally, the low-protein diet-consumption hens gained less weight, which could mean that they consumed less protein.

They hypothesized that the birds were in a state of negative nitrogen balance, and any improvements in retention were reduced. In other investigations, Tesfaye *et al*. (2019) reported that hens provided a diet containing 16.5% CP and 2800 ME kcal/kg demonstrated significantly better EM, feed efficiency, and profitability than hens fed other lower potentiality diets. However, hens fed diets containing 16.5%-2800, 17%-2900, and 16%-2700 ME kcal/kg showed no significant differences in FBW, EP, EW, or FC.

The current study shows that laying hens' feed efficiency, EN, EW, daily EM, and EP were all negatively impacted when the protein content was decreased from 18% to 14%. Consistent with the results of Sun *et al*. (2022), a laying hen's feed efficiency decreased when its protein level was decreased from 16% to 14%. It's unclear why laying hens on low-protein diets supplemented with amino acids performed less than optimally. It is well known that hens don't specifically need protein but rather amino acids, which the body needs to operate after breaking down protein. Consequently, it is unlikely that the lower performance was caused by a low-protein diet since the necessary amino acids were obtained. According to some researchers, laying hens may not require as much as they need for certain important amino acids, such as valine and isoleucine (Calderson and Jensen 1990), tryptophan, and/or isoleucine (Jensen 1991). It is possible that the conversion of essential amino acids in diets to a degree where they become restricting for optimal performance also occurs when the non-essential nitrogen component of the diet is limiting (Adeyemo *et al*., 2012). In line with this investigation, Fonseca *et al.* (2021) and Ashour *et al*. (2022) indicated that feeding laying quails high metabolizable energy diet have a superior FC than those with low metabolizable energy. These findings are consistent with those of the present study. El-Hindawy *et al*. (2021) observed that feeding quail diets with high crude protein content increased EP, EW, EM and FCR. Further confirmation was found by Jesuyon *et al*. (2021) who noted that egg weight of laying quail was increased in response to feeding high crude protein diet. Salih *et al*. (2021) indicated that higher crude protein diets in crude protein resulted in improved FCR, EP, and EM. Salih *et al*. (2021) indicated that higher crude protein diets resulted in improved FCR, EP and EM.

In another studies, Macelline *et al*. (2021) and Mnisi *et al*. (2022) suggested that higher crude protein concentrations may enhance laying quail EP, as the synthesis of eggs depends on the protein obtained from meals. Conversely, Hijab and Albaddy (2022) showed that diets with different metabolizable energy levels did not affect quail's egg weight. Kumari *et al*. (2016) found that from 25 to 44 weeks of age, different protein levels in the WLH layers' diet had no effect on EP, FI or EW. A study by Parenteau *et al.* (2020) reported that chickens fed a low-protein diet may have different essential amino acid requirements. However, Sharif *et al.* (2020) noticed that lowering energy and lysine in late-laying hens has no effect on blood metabolites, EP, EW, or egg quality measures.

In the current investigation, raising methionine levels by 0.51 or 0.39% is necessary to maintain a steady level of SAA, which is reflected in an increase in feed consumption, could be the cause of the decrease in PER, EER and FCR in hens given a low-energy diet. Besides that, a reduced dietary CP level was associated with decreased egg weight and increased feed intake, which led to poor feed efficiency. Whereas birds age, laying rate, the ratios of the components in the egg, the nutritional energy content, the amino acids diet's balance and other factors; all affect the laying hens' efficiency in utilizing amino acids. Saki *et al*. (2012) concluded that while keeping an energy level of 2830 kcal/kg, raising the methionine (Met.) level from 0.24 to 0.34% led to a significant increase in EP, EW and EM, as well as poor feed conversion ratio. Nevertheless, these traits were unaffected by more Met. increases. However, this strain does not appear to be able to compensate the low dietary ME and CP content by increasing feed intake to the degree where it satisfies requirements for energy, protein, and/or other nutrients (amino acids) in order to give the best performance.

Actually, providing a low-protein diet with supplements of essential amino acids (EAA) can improve the ability to utilize dietary crude protein and decrease excretion of nitrogen without impairment in production. (Laudadio *et al*., 2012).

Generally, it is essential to maintain the supply and balance of amino acids in poultry diets according to the birds' nutritional needs in order to successfully reduce crude protein levels while maintaining good performance results. Therefore, it is still unclear what the essential amino acid requirements are for a low-protein layers diet. The level of free amino acids in the diet must be taken into account (Harn *et al*., 2021).

Egg quality and reproductive parameters:

Data indicated that dietary energy, protein levels and their interactions had insignificant (P > 0.05) effect on egg quality parameters, as well as fertility, hatchability percentages and chick weight at hatching as presented in Tables 5 and 6. Data from Table 5 show that egg shape index, albumin, yolk and shell percentages were not significantly affected by energy or protein levels. As well, they hadn't a substantial effect on shell thickness (mm), Hough unit, yolk index %, specific gravity, or ESA. All egg quality traits under study were not significantly (P < 0.05) impacted by the interactions between dietary energy and protein levels.

Increasing the energy level to 2850 kcal/kg diet exhibited insignificant improvement in fertility, hatchability and chick weight (Table 6). Also, eggs produced from hens fed low-protein diets fortified with methionine (14 or 16% CP), scored results similar to those fed 18% crude-protein diet in terms of fertility, hatchability and chick weight. In addition, the interaction between CP and energy levels had a significant (P > 0.05) impact on fertility, hatchability and chick weight. Hens received diets containing 2850 kcal/kg attained the best values of the previous attributes compared to those received diets containing 2700 kcal/kg, regardless of protein levels. These results are consistent with the findings by Tenesa *et al*. (2016) who stated that hens given 17.5% CP (as control), 17%, and 16.5% CP supplemented with lysine, threonine, and methionine; illustrated no statistically significant changes between the treatment groups in terms of Haugh units, weight percentage of albumen and yolk, eggshell weight, and thickness. Similar findings were found by Tesfaye *et al*. (2019), who reported that hens fed diets with varying protein-energy levels (16-2750, 16.5-2800, 17-2900, and 16% CP-2700 ME kcal/kg diets) did not exhibit significant changes in egg quality, fertility or hatchability. The findings of Alderey and El-Weshahy (2019), Alderey (2020) and Alderey and Dorgham (2024) indicated that there were no statistically significant variations in fertility, hatchability and egg quality among laying fed diets with different protein-energy levels (14, 16 and 2700 or 2850 ME kcal/kg diets). Yakout (2010) reported no significant differences in egg quality traits between inclusion protein levels of 17.5, 15, and 13% CP supplemented with Met., Lys. and Trp in laying diets. Furthermore, Zhang *et al*. (2021) demonstrated that feeding ducks varying CP levels (13.5–17.5%) did not result in significant differences in egg quality. They followed to indicate that the addition of energy and nutrient density diets (2700 or 2800 kcal/kg AMEn) had no effect on eggshell strength, thickness, or Haugh unit. Hussein *et al*. (2010) observed that CP and ME levels had no significant impact on the reproductive characteristics or egg quality of Sinai laying hens. Ding *et al.* (2016) showed no significant interaction between CP (14.5, 15, and 15.5%) and ME (2650 and 2750 kcal/kg) on egg quality, which was in contrast to the findings of Zeweil *et al*. (2011), who found that a higher CP level significantly reduced the proportion of hatched Baheij hen chicks. According to Kang *et al*. (2018) and Bagheri *et al*. (2020) they found that dietary energy and nutrient density had no significant effects on the majority of measured parameters, including egg weight, egg shell thickness, egg shape index, yolk weight specific gravity, shell relative weight, and Haugh unit.

Blood parameters:

The effects of dietary energy and protein levels on some blood characteristics are presented in Table 7. The results showed that major blood measures, including total protein, albumin, globulin, AST, ALT, and glucose, were not significantly affected by energy levels. However, when birds fed diet contained high energy; there was a highly significant (P≤ 0.01) increase in cholesterol levels. Furthermore, there was not a significant effect in terms of dietary protein levels on blood characteristics. Nevertheless, birds fed a diet containing 14% protein fortified with methionine exhibited a significant decrease (P≤ 0.01) in their AST values, while birds fed 18 % protein diet showed a highly significant increase (P≤ 0.01) in their ALT values compared to other levels.

As for interactions among the studied factors (Table 7), results displayed significant variations in blood plasma's AST, ALT and cholesterol, but total protein, albumin, globulin, or glucose were not significantly affected. When compared to other treatments, hens fed a low-protein diet (14% CP) with two energy levels had the lowest values of AST. Hens fed diet containing 16% protein fortified with methionine at a low energy level scored the highest value of AST compared to other groups, while those fed 2700 kcal and 18% protein had the highest ALT values. However, hens fed low-energy-protein diets had the lowest ALT values compared to other treatments. Birds fed a low-energy level exhibited the lowest values of cholesterol regardless of protein levels, followed by hens fed a low-protein level at a high-energy level; while hens fed a diet containing a high-protein level with a high-energy level recorded the highest value of cholesterol.

These findings are consistent with those of Alderey (2020), who found that although feeding a low-energy diet significantly (P≤0.01) reduced the cholesterol level, most blood parameters including total protein, albumin, globulin, AST, ALT, and glucose did not significantly change compared to a high-energy diets, while other parameters remained unchanged. Hens fed 18 % CP diet showed a significant rise in ALT compared to those fed 14 % CP diet. Significant differences were noticed in the values of AST and ALT when the protein content was increased. Nofal *et al*. (2018) found that laying hens fed high-energy diet (2800 kcal/kg) showed higher blood plasma cholesterol levels compared to a low-energy diet (2600 kcal/kg); nevertheless, albumin, glucose, and AST activity levels were unaffected. In line with Kout El-kloub *et al*. (2005), who showed that feeding laying hens different levels of energy and protein had no effect on blood parameters. Conversely, Zeweil *et al*. (2011) found that laying hens fed a diet containing 16% CP had higher plasma total protein and globulin levels than hens fed a diet containing 12 or 14% CP.

Economic efficiency:

Results of economic efficiency are presented in Table 8. It was clear that giving hens a high-energy diet increased their body weight, which in turn increased their revenue from both changes in body weight and fertile eggs/hens compared to those fed low-energy diets. This ultimately reflected an increase in net revenue as well as an increase in economic efficiency.

Regarding protein levels, it is logical that increasing the level of protein resulted in increases in feed costs. However, increasing the protein level led to a gradual increase in revenue CBW, fertile eggs/hen and net revenue, but birds provided with a diet containing 14% or 16% protein fortified with methionine achieved an improvement in economic efficiency compared to those fed 18-protein diet. This is due to an increase in revenue from CBW, fertile eggs/hen and the net revenue of the diet containing 18% protein, which could not compensate for the increase in feed costs.

The effect of the interaction between dietary energy and protein levels on the economic efficiency of Sinai laying hens is shown in Table 8. It was demonstrated that all birds fed diets containing protein at levels of 14, 16, or 18% with 2850 kcal/kg achieved the highest economic efficiency compared to their counterparts with 2700 kcal/kg. However, the highest economic efficiency was attained by hens fed a high-energy diet including 16% protein followed by hens provided a diet containing 14% CP with the same energy level in comparison with other diets. This is because the diet containing 18 CP with high or low-energy level was the highest feed cost compared to other diets. Hence, it is economically optimal to feed Sinai laying hens a diet that contains 16% protein fortified with methionine and 2850 kcal/kg diet. Our findings are in line with those of Alderey (2020), who found that giving Silver Montazah laying hens diets containing 2850 kcal ME/kg diet with 14% or 16% CP fortified with methionine throughout 24–40 weeks of age did not have a negative impact on profitability.

CONCLUSION

It could be concluded that Sinai laying hens fed a diet containing 16% protein fortified with methionine and 2850 kcal/kg diet were economically optimal.

Table (1): The composition and calculated analysis of the experimental diets fed to Sinai laying hens

Dietary energy levels (kcal ME/Kg)	**2700**			**2850**		
Dietary crude protein levels (%)	**14**	**16**	**18**	**14**	**16**	**18**
Ingredients,%						
Yellow corn, %	65.50	62.50	57.50	67.35	62.70	59.30
Soy bean 44, %	13.0	20.50	25.50	14.81	20.50	25.0
Gluten, 62 %	3.00	2.50	3.00	2.50	3.00	4.00
Wheat bran, %	8.15	4.50	3.50	4.00	2.035	0.00
Limestone, %	7.90	7.72	7.70	7.50	7.70	7.60
Di-calcium phosphate	1.60	1.60	1.60	1.60	1.60	1.60
Soya oil	0.00	0.00	0.60	1.42	1.80	1.90
Salt	0.30	0.30	0.30	0.30	0.30	0.30
***Vitamin and Mixture.**	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.15	0.03	0.00	0.11	0.00	0.00
Methionine	0.10	0.05	0.00	0.11	0.065	0.00
Total	100	100	100	100	100	100
****Calculated analysis**						
CP, %	14.08	16.11	18.04	14.02	16.05	18.05
ME kcal/kg	2700	2705	2703	2855	2854	2850
CF, %	3.456	3.419	3.629	3.159	3.222	3.269
EE, %	3.011	2.918	2.114	2.992	2.838	2.716
Ca, %	3.342	3.291	3.296	3.191	3.28	3.354
Avi. P, %	0.431	0.438	0.444	0.435	0.430	0.444
Lys., %	0.793	0.833	0.443	0.733	0.792	0.920
Meth., %	0.511	0.411	0.439	0.391	0.480	0.337
Methionine + cystiene %	0.640	0.640	0.648	0.642	0.654	0.655

*Premix at 0.30 of the diet supplies, the following per kg of the diets: Vit. A 10000 I.U, Vit.D_3 2000 I. U, Vit. E 10 mg, Vit. K_1 mg, Vit.B_1 1 mg, Vit.B_2 5 mg, Vit.B_6 1.5 mg, Vit.$B_1$2 0.01 mg, Folic acid 0.35 mg, Biotin 0.05 mg, Pantothenic acid 10 mg, Niacin 30 mg, Choline 250 mg, Fe 30 mg, Zn 50 mg, Cu 4 mg, I 1 mg and Se 0.1 mg.

** according to NRC 1994.

Table (2): Effect of dietary different levels of energy and protein and their interactions on live body weight, daily feed intake, daily protein intake and daily energy intake of Sinai laying hens.

Treatments		Initial BW (g)	Final BW (g)	Chang in BW (CBW,g)	Daily feed intake (g)	Daily protein intake (g)	Daily energy intake (kcal)
Dietary energy levels (kcal/kg)							
2700		1453.09±6.35	1583.27 ^{b} ±5.30	130.18 ^{b} ±5.65	105.69 ^{a} ±0.56	16.96 ^{a} ±0.22	285.64 ^{a} ±1.52
2850		1454.40±6.38	1606.18 ^{a} ±5.51	151.78 ^{a} ±6.72	97.80 ^{b} ±0.66	15.66 ^{b} ±0.23	279.03 ^{b} ±1.91
Sig.		NS	**	*	**	**	**
Crude protein levels% (CP %)							
14		1450.47±7.85	1582.73±6.55	132.27±7.91	103.80 ^{a} ±1.00	14.59 ^{c} ±0.14	288.02 ^{a} ±2.09
16		1456.50±5.82	1598.87±6.62	142.37±6.99	102.30 ^{a} ±1.13	16.45 ^{b} ±0.19	283.96 ^{a} ±2.13
18		1454.27±9.40	1602.57±7.22	148.30±8.46	99.13 ^{b} ±0.81	17.89 ^{a} ±0.14	275.02 ^{b} ±1.63
Sig.		NS	NS	NS	**	**	**
Interactions							
ME(kcal/kg)	**CP%**						
2700	**14**	1449.40±11.05	1575.13 ^{c} ±8.54	125.73 ^{b} ±7.77	107.53 ^{a} ±0.62	15.14 ^{d} ±0.09	290.34 ^{a} ±1.67
	16	1454.40±10.15	1585.13 ^{b} ±9.17	130.73 ^{ab} ±9.36	107.40 ^{a} ±0.77	17.30 ^{b} ±0.12	290.52 ^{a} ±2.09
	18	1455.47±12.38	1589.53 ^{ab} ±10.0	134.07 ^{ab} ±12.28	102.13 ^{b} ±0.81	18.42 ^{a} ±0.15	276.07 ^{b} ±2.17
2850	**14**	1451.53±11.52	1590.33 ^{b} ±9.83	138.80 ^{a} ±13.88	100.07 ^{b} ±1.34	14.03 ^{e} ±0.19	285.69 ^{a} ±3.82
	16	1458.60±6.07	1612.60 ^{a} ±8.40	154.00 ^{ab} ±9.77	97.20 ^{c} ±1.01	15.60 ^{c} ±0.16	277.98 ^{b} ±2.87
	18	1453.07±14.58	1615.60 ^{a} ±9.57	162.53 ^{a} ±10.81	96.13 ^{c} ±0.87	17.35 ^{b} ±0.16	282.33 ^{b} ±2.49
Sig.		NS	*	*	**	**	**

^{a,b}….For each of the main effects, means in the same column bearing different superscripts differ significantly
NS = not significant *:P< 0.05, **:P< 0.01).

Table (3): Effect of dietary different levels of energy and protein and their interactions on protein efficiency ratio (PER), metabolizable energy efficiency (MEE) and feed conversion ratio (FCR) of Sinai laying hens.

Treatments		**PER**	**MEE**	**FCR**
Dietary energy levels (kcal/kg				
2700		54.62 [a] ±0.55	9.23 [a] ±0.08	3.41 [a] ±0.03
2850		48.28 [b] ±0.65	8.62 [b] ±0.09	3.02 [b] ±0.03
Sig.		**	**	**
Crude protein levels% (CP %)				
14		47.58 [c] ±0.77	9.39 [a] ±0.12	3.39 [a] ±0.05
16		51.34 [b] ±0.81	8.86 [b] ±0.10	3.19 [b] ±0.05
18		55.43 [a] ±0.64	8.52 [c] ±0.07	3.07 [b] ±0.04
Sig.		**	**	**
Interactions				
ME (kcal/kg)	**CP%**			
	14	50.71 [d] ±0.54	9.72 [a] ±0.10	3.60 [a] ±0.04
2700	**16**	55.14 [b] ±0.56	9.26 [b] ±0.09	3.42 [b] ±0.04
	18	58.02 [a] ±0.59	8.69 [cd] ±0.09	3.22 [c] ±0.03
	14	44.45 [f] ±0.86	9.05 [c] ±0.18	3.17 [c] ±0.06
2850	**16**	47.55 [e] ±0.57	8.45 [de] ±0.10	2.96 [d] ±0.04
	18	52.84 [c] ±0.61	8.34 [e] ±0.10	2.93 [d] ±0.03
Sig.		**	**	**

[a,b]….For each of the main effects, means in the same column bearing different superscripts differ significantly *:P< 0.05, **:P< 0.01).

Table (4): Effect of dietary different levels of energy and protein and their interactions on egg number, egg weight, daily egg mass and hen day egg production rate of Sinai laying hens.

Treatments		Egg number	Egg weight (g)	Daily egg mass (g)	hen-day egg production rate %
Dietary energy levels (kcal/kg					
2700		64.90 [b] ±0.30	50.12 [b] ±0.23	30.98 [b] ±0.17	61.80 [b] ±0.29
2850		66.38 [a] ±0.29	51.10 [a] ±0.28	32.30 [a] ±0.16	63.21[a] ±0.28
Sig.		**	**	**	**
Crude protein levels% (CP %)					
14		64.50 [b] ±0.40	49.89 [b] ±0.42	30.66 [b] ±0.23	61.43 [b]±0.39
16		66.06 [a] ±0.35	50.93 [a] ±0.22	32.05 [a] ±0.19	62.92 [a] ±0.34
18		66.34 [a] ±0.33	51.00 [a] ±0.27	31.23 [a] ±0.18	63.18 [a] ±0.31
Sig.		**	*	**	**
Interactions					
ME (kcal/kg)	**CP%**				
2700	**14**	63.50 [c] ±0.52	49.29 [b] ±0.40	29.81 [c] ±0.24	60.48 [c] ±0.49
	16	65.19 [b] ±0.47	50.57 [ab]±0.29	31.40 [b] ±0.23	62.08 [b] ±0.45
	18	66.00 [ab] ±0.38	50.50 [ab]±0.44	31.74 [b] ±0.18	62.86 [ab] ±0.36
2850	**14**	65.50 [ab] ±0.51	50.50 [ab] ±0.72	31.50 [b] ±0.24	62.38 [ab] ±0.48
	16	66.94 [a] ±0.42	51.29 [a] ±0.32	32.70 [a] ±0.21	63.75 [a] ±0.40
	18	66.69 [a] ±0.54	51.50 [a] ±0.25	32.71 [a] ±0.26	63.51 [a] ±0.51
Sig.		**	*	**	**

[a,b]….For each of the main effects, means in the same column bearing different superscripts differ significantly *:P< 0.05, **:P< 0.01)

Table (5): Means of egg quality measurements as affected by dietary different levels of energy and protein and their interactions of Sinai laying hens

Treatments		Egg shape index %	Egg components			Shell thickness (mm)	Hough Unit	Yolk index %	Specific gravity	ESA
			Albumen %	Yolk %	Shell %					
Dietary energy levels (kcal/kg										
2700		79.17±1.42	55.34±0.40	30.73±0.39	13.93±0.24	34.00±0.65	81.41±1.22	47.95±0.79	1.109±0.0	64.68±0.99
2850		78.76±1.18	54.43±0.56	31.71±0.49	13.85±0.24	34.33±0.41	80.56±2.01	48.21±0.62	1.109±0.0	63.24±0.81
Sig.		NS	NS	NS	NS	NS	NS	NS	NS	NS
Crude protein levels% (CP %)										
14		78.85±2.11	55.00±0.68	30.79±0.56	14.22±0.36	34.50±0.67	81.42±2.97	48.80±0.59	1.111±0.0	63.87±0.74
16		77.75±1.22	55.09±0.54	30.90±0.48	13.97±0.13	33.83±0.60	81.53±1.86	47.57±0.93	1.109±0.0	64.67±1.13
18		80.29±1.25	54.57±0.69	31.94±0.63	13.49±0.28	34.17±0.75	80.00±0.91	47.87±1.02	1.106±0.0	63.33±1.50
Sig.		NS	NS	NS	NS	NS	NS	NS	NS	NS
Interactions										
ME (kcal/kg)	**CP%**									
2700	**14**	80.07±3.77	55.58±0.83	30.17±0.22	14.24±0.67	34.33±1.33	82.02±1.42	48.33±1.13	1.111±0.0	64.17±1.55
	16	76.45±1.92	55.61±0.26	30.31±0.27	14.08±0.12	34.00±1.00	81.45±3.47	47.24±0.95	1.110±0.0	65.20±2.25
	18	80.99±0.70	54.83±1.00	31.71±1.01	13.46±0.27	.33.67±1.45	80.77±1.84	48.28±2.20	1.106±0.0	64.67±2.02
2850	**14**	77.63±2.57	54.42±1.15	31.40±1.08	14.19±0.46	34.67±0.67	80.82±6.46	49.28±0.49	1.111±0.0	63.57±0.49
	16	79.06±1.45	54.57±1.06	31.57±0.82	13.86±0.25	33.67±0.88	81.62±2.29	47.90±1.81	1.109±0.0	64.15±1.00
	18	79.58±2.61	54.31±1.16	32.17±0.95	13.51±0.57	34.67±0.67	79.24±0.40	47.46±0.39	1.107±0.0	62.00±2.31
Sig.		NS	NS	NS	NS	NS	NS	NS	NS	NS

All means in the same column were not significant.

Table (6): dietary different levels of energy and protein and their interactions on fertility, hatchability and chick weight of Sinai laying hens.

Treatments		Fertility %	Hatchability of fertile eggs %	Hatchability of total eggs %	Chick weight (g)
Dietary energy levels (kcal/kg					
2700		88.13±0.79	87.33±0.39	77.34±0.76	35.47±0.25
2850		88.69±0.30	88.66±0.70	78.26±0.57	35.90±0.20
Sig.		NS	NS	NS	NS
Crude protein levels% (CP %)					
14		88.55±1.00	87.38±0.52	77.39±0.99	35.90±0.34
16		88.71±0.43	88.06±0.59	78.13±0.49	35.90±0.22
18		87.97±0.72	88.55±1.03	77.88±1.00	35.25±0.28
Sig.		NS	NS	NS	NS
Interactions					
ME (kcal/kg)	**CP%**				
2700	**14**	88.42±2.17	86.80±0.61	76.76±2.11	35.70±0.56
	16	88.04±0.48	87.47±0.93	78.12±1.00	35.70±0.34
	18	87.94±1.61	87.72±0.59	77.12±0.97	35.00±0.39
2850	**14**	88.68±0.56	87.96±0.80	77.99±0.25	36.10±0.41
	16	89.38±0.51	88.65±0.72	78.13±0.43	36.10±0.28
	18	88.00±0.14	89.37±2.07	78.65±1.88	35.50±0.34
Sig.		NS	NS	NS	NS

All means in the same columns are not significant

Table (7): Effect of dietary different levels of energy and protein and their interactions on blood parameters of Sinai laying hens

Treatments		Total protein g/dl	Albumin g/dl	Globulin g/dl	AST (U/L)	ALT (U/L)	Cholesterol mg / d	Glucose mg/dl
Dietary energy levels (kcal/kg								
2700		4.42±0.05	2.61±0.05	1.81±0.07	20.00±1.31	26.77±1.05	114.89±0.42^{b}	249.00±0.62
2850		4.51±0.06	2.63±0.03	1.88±0.04	17.33±0.73	26.79±0.62	121.67±1.41^{a}	250.11±0.51
Sig.		NS	NS	NS	NS	NS	**	NS
Crude protein levels% (CP %)								
14		4.53±0.06	2.68±0.05	1.85±0.08	15.50 ^{c} ±0.43	25.42 ^{b} ±0.71	117.17±1.19	249.83±0.40
16		4.52±0.07	2.65±0.04	1.87±0.08	21.50 ^{a} ±1.38	25.15 ^{b} ±0.33	117.67±1.45	248.83±0.83
18		4.35±0.06	2.53±0.04	1.82±0.05	19.00 ^{a} ±0.86	29.77 ^{a} ±0.53	120.00±2.77	250.00±0.86
Sig.		NS	NS	NS	**	**	NS	NS
Interactions								
ME (kcal/kg)	**CP%**							
2700	**14**	4.47±0.09^{bc}	2.67±0.09	1.80±0.12	16.00 ^{cd} ±0.58	24.00 ^{e} ±0.46	115.00 ^{c} ±0.58	249.67±0.67
	16	4.47±0.06^{bc}	2.70±0.06	1.77±0.06	24.00 ^{a} ±1.73	25.53 ^{cd} ±0.46	114.67 ^{c} ±0.88	247.67±0.88
	18	4.33±0.09^{c}	2.47±0.03	1.87±0.03	20.00 ^{b} ±1.15	30.77 ^{a} ±0.58	115.00 ^{c} ±1.00	249.67±1.45
2850	**14**	4.60±0.12^{ab}	2.70±0.06	1.90±0.07	15.00 ^{d} ±0.58	26.83 ^{c} ±0.53	119.33^{bc} ±1.45	250.00±0.58
	16	4.57±0.09^{ab}	2.60±0.06	1.97±0.07	19.00 ^{bc} ±0.58	24.77 ^{de} ±0.43	120.67 ^{ab} ±0.88	250.00±1.15
	18	4.37±0.09^{a}	2.60±0.06	1.77±0.07	18.00 ^{bcd} ±1.15	28.77 ^{b} ±0.26	125.00 ^{a} ±3.51	250.33±1.20
Sig.		NS	NS	NS	**	**	**	NS

^{a,b}… For each of the main effects, means in the same column bearing different superscripts differ significantly NS = not significant, **:P< 0.01).

Table (8): dietary different levels of energy and protein and their interactions on economic efficiency (EE) of Sinai laying hens.

Treatments		Total feed intake of hen(kg)	Price/ Kg feed (LE)	Total feed cost (LE/ hen)	revenue CBW (LE/ hen)	revenue of fertile eggs/hen	Total revenue	Net revenue	Relative EE%
Metabolizable energy levels (kcal/kg)									
2700		11.84	16.34	193.47	14.29	519.17	533.46	340.00	175.74
2850		10.96	16.97	186.00	16.70	531.73	548.43	362.43	194.85
Crude protein levels% (CP%)									
14		11.63	15.83	184.10	14.53	516.00	530.53	346.43	188.17
16		11.46	16.67	191.04	15.64	528.52	544.16	353.12	184.84
18		11.11	17.47	194.10	16.31	531.84	548.15	354.10	182.43
Interactions									
ME (kcal/kg)	**CP%**								
	14	12.04	15.50	186.62	13.79	508.00	521.79	335.17	179.60
2700	16	12.03	16.33	196.45	14.34	521.52	535.86	339.41	172.77
	18	11.44	17.18	196.54	14.75	528.00	542.75	346.21	176.15
	14	11.21	16.15	181.04	15.27	524.00	539.27	358.23	197.87
2850	16	10.89	17.00	185.13	16.94	535.52	552.46	367.33	198.42
	18	10.77	17.76	191.28	17.88	535.68	553.56	362.28	189.40

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الملخص العربى

تأثير التغذية على مستويات مختلفة من الطاقة والبروتين المدعمة بالمثيونين على الأداء الإنتاجى والتناسلى لدجاج سيناء البياض

عبد الفتاح عبد الحميد الدرعى- سالم عبد العزيز درغام
معهد بحوث الإنتاج الحيوانى – مركز البحوث الزراعية

يعد البروتين ومستويات الطاقة الممثلة من بين أهم العناصر الغذائية لتقييم النظام الغذائي للدواجن. أجريت التجربة على ١٤٤ دجاجة بياضة سيناء (٢٥ أسبوع) مقسمة إلى ٦ مجموعات (مستويان للطاقة ٢٧٠٠ و ٢٨٥٠ كيلو كالوري/كجم عليقة مع ثلاثة مستويات من البروتين ١٤ و١٦ % و ١٨ % مع تدعيم المستويين ١٤ و ١٦% بالمثيونين للوصول إلى مستوى الأحماض الأمينية الكبريتية مساوى لذلك المستوى الموجود بـ المستوى ١٨% بروتين في التصميم التجريبي العاملي (٣ .(2×

يمكن تلخيص النتائج على النحو التالي:

- أظهرت زيادة مستويات الطاقة أو البروتين تحسنا معنويا (P<٠.٠١) في وزن الجسم النهائي ، والتغير وزن الجسم، ومعامل التحويل الغذائى، وعدد البيض، ووزن البيضة ، وكتلة البيض اليومى ومعدل إنتاج بيض /دجاجة، في حين أن التغذية على علائق منخفضة الطاقة أدت إلى زيادة معنوية (P<٠.٠١) في المستهلك اليومى من العليقة، والمأكول اليومى من البروتين، والطاقة، والكفاءة النسبية للبروتين وكفاءة الطاقة الممثلة. كما أدت الزيادة في مستويات البروتين إلى زيادة معنوية (P<٠.٠١) في المأكول اليومى من البروتين والكفاءة النسبية للبروتين.

- سجلت الطيور التى تغذت على علائق تحتوي على ١٦% أو ١٨% من البروتين عند مستوى الطاقة المرتفع أعلى المتوسطات في وزن الجسم النهائي ، التغير وزن الجسم، عدد البيض، وزن البيضة، كتلة البيض اليومية ومعدل إنتاج البيض/ يوم بدون أي اختلافات معنوية بينهما.

- لم تتأثر معايير جودة البيض ونسبتى الخصوبة والفقس بشكل معنوي بأي من العوامل المدروسة.

- أدى زيادة الطاقة إلى ٢٨٥٠ كيلو كالوري/كجم إلى زيادة معنوية (P<٠.٠١) في الكوليسترول، كما أظهرت زيادة مستويات البروتين إلى ١٨% زيادة في AST ومستويات ALT في الدم مقارنة بالمعاملات الأخرى.

- يمكن أن نخلص الى أن التدعيم بالميثيونين فقط غير قادرًا على التعويض بشكل فعال عن انخفاض CP في النظام الغذائي. لذلك، لا يزال من غير الواضح ما هي المتطلبات الغذائية للأحماض الأمينية الأساسية للدجاج البياض الذي يتغذى على علائق منخفضة البروتين.

من الناحية الاقتصادية، فإنه من الأفضل تغذية دجاج سيناء البياض على عليقة تحتوي على ١٦ أو ١٤% بروتين مدعم بالمثيونين مع ٢٨٥٠ كيلوكالورى/كجم عليقة.