INFLUENCE OF LOW-PROTEIN LEVELS FORTIFIED WITH METHIONINE AND ENERGY ON PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF SILVER MONTAZAH LAYING HENS

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SUMMARY

The objective of the present experiment to determine the extent to which the crude protein (CP) content of laying hen diets can be reduced, based on fortified with methionine (Met.) to reach a level of sulfur amino acids equal with high-protein level and their effects on productive and reproductive performance of silver Montazah laying hens during 24-40 wks of age. One hundred and eighty hens 24-weeks old were housed in individually cages in factorial experimental design (2X3) involves 30 birds in each treatment. The experimental diets were formulated with two dietary metabolizable energy levels (low energy = 2700 and high energy = 2850 kcal ME / kg diet) and three dietary protein levels 14% low crude protein; 16% moderate crude protein and 18% high crude protein. The diets of 14 and 16% CP were fortified with methionine to reach the same level of SAA 18% CP-diet. Feeds and water were offered ad libitum. Fertility and hatchability percentage were determined at 37, 38 and 39 wk of age. All hens from each treatment group were artificially inseminated twice a week with a fixed volume of diluted semen (1:1) from cockerels fed diet containing 16% CP and 2750 kcal/kg diet. Results are summarized as follows: Significant increases were observed in final body weight (FBW), body weight change (BWC), metabolizable energy efficiency ratio (EER) feed conversion ratio (FCR), Egg production parameters; egg number (EN), egg weight (EW), daily egg mass (EM), hen-day egg production rate% (HDEP), cholesterol level in blood plasma and economic efficiency of feed parameters (EEF) due to feeding on high-energy diets, while birds fed on low-energy diets resulted in significantly (P≤0.01) increased in feed intake, daily protein intake, daily energy intake and daily methionine intake than that fed high-energy diet. The same manner was observed in respect of protein levels, where increasing protein content in the diet had a significant improvement (P≤0.01) in final body weight, change (BWC), daily protein intake, energy efficiency ratio, feed conversion ratio, egg number, egg weight, egg mass, hen day egg production rate, AST, and ALT in blood plasma. Interaction between energy and protein levels were significant effects on most studied traits, there were positive effects of different protein levels at high energy level on body weight, body weight change, energy efficiency ratio, feed conversion, egg number, daily egg mass, hen-day egg production rate%, egg fertility%, hatchability%, chick weight, most blood traits and economic efficiency of feed. However, neither energy nor protein levels significantly affected on egg quality, egg fertility percentage and chick weight. Based on performance outcomes hens fed high-energy diet with 14% or 16% protein level fortified with DL-methionine succeed in recording egg number and hen-day egg production rate like those fed on 18% protein. It could be concluded that reducing protein level fortified with DL-methionine in Montazah laying hens diets had beneficial effects on some traits but not all traits. From economic analysis of this study it can be used diets containing 2850 kcalME/kg diet with 14% or 16% CP fortified with methionine in feeding Silver Montazah laying hens during 24-40 weeks of age without negative effect on profitability.

Keywords: Dietary metabolizable energy and crude protein levels, methionine, Montazah laying hens productive and reproductive performance.

INTRODUCTION

Protein and amino acids are the most cost ingredient in the diet. The efficiency of dietary protein utilization depends on the amount, composition, and digestibility of the amino acids (AA) in the diet, hence determination of optimum level of amino acids in feed formulation is fundamental not only in economics of production also in addition to reduction of nitrogen loss in poultry faces which alleviate of environmental pollution.
With acute increases in energy and protein cost, it is should good understand of how to maximize benefits of dietary feed rations at different protein, amino acids and energy levels to obtain optimize productive and reproductive performance. Increasing levels of protein (Nahashon et al., 2010, Keshavarz and Nakajima, 1995, Leeson, 1989), methionine (Keshavarz, 1995), and lysine (Zimmerman, 1997) improved production parameters especially egg weights. However, a reduction in the dietary concentration of CP may result in unbalanced amino acid concentrations and may also change the optimal requirements of the limiting amino acids (methionine, lysine) at lower dietary levels of CP in the same time excess of the requirements from amino acids may break down production through several interactions and may occur in N environmental pollution. Similarly, If dietary metabolizable energy needs to be reduced, then essential amino acids also should be reduced, but to a lesser extent. The prospect of lowering dietary protein has become actuality because of the availability of Lys, Met, Thr, and Trp in the market.

Many researchers have been published on Met and TSAA requirements and their effects on laying hen performance. However, there is a wide range in recommended requirement of Met. and TSAA for laying hens. Saki et al. (2012) who found that increasing Met. level from 0.24 to 0.34% with constant energy level 2830 kcal/kg resulted in significantly increased egg production, egg weight, egg mass, egg content, and feed intake and improved feed conversion ratio (p≤0.05). However, further Met. increases, from 0.34 to 0.49%, no longer influenced these parameters. Ahmad et al. (1997) indicated that performance of laying hens had not affected as a result feeding on TSAA levels ranging from 580 to 660 mg/h/d. Meluzzi et al. (2001) fed laying hens on diets at different protein concentrations: 170 (control), 150 and 130 g/kg CP with adequate concentrations of lysine, sulfur amino acids, tryptophan and threonine and found that a low-CP diet supplemented with amino acids sustained performance during the initial 8 wk of the experiment, after which EP and EM reduced compared with birds fed diets with the recommended CP level.

In general, nutrient specifications and amino acid specification should be adjusted to the economic conditions including sources income and return.

The present study was conducted to determine how much dietary crude protein could be reduced, by fortified with methionine to reach constant level of sulfur amino acid and reflected it on productive and reproductive performance of Montazah laying hens during production phase from 24 to 40 weeks of age.

MATERIALS AND METHODS

The experiment was carried out at Gimmizah Research Station, Animal Production Research Institute, Agricultural. Research. Center, Ministry of Agriculture. A total of 180 Silver Montazah laying hens 24-weeks old used in this experiment. The experimental birds were reared in floor pens up to 27 weeks of age then they were transferred into individual battery cages and given one week to adapt in battery system. The birds were randomly allocated to six treatment group had nearly similar body weight in factorial experimental design (2X3). the experimental diets consists of two metabolizable energy (ME) levels, 2700 as low energy and 2850 as high energy kcal/kg, and three dietary protein levels which referred to 18% = high CP, 16% = medium CP, or 14% = low CP. The levels of 14 and 16% CP fortified with amino acid methionine to be equated with diet content 18% protein of SAA. The proposal of reducing protein diets fortified with amino acid methionine to equal the content of the high- protein diets from SAA and reflected on productive and reproductive performance as well as reducing the cost of the diet. The composition of the experimental diets is presented in Table (1). The experiment period was lasted to 40-wks age. Feed and water were provided ad-libitum throughout the experiment. Hens were maintained on a 16L: 8D during the experimental period.

Measurements:

Live body weight of each hen was recorded in the beginning and the end of experimental period. Feed intake, egg number (EN) and egg weights (EW) were recorded while, daily protein intake, daily energy intake, feed conversion ratio (FCR), egg mass (EM), protein efficiency ratio (PER) and energy efficiency ratio were calculated.

At 34, 35 and 36 wk of age, 30 eggs per treatment group were collected at random to determine the egg quality measurements. Shape index was calculated by divided widths into lengths multiple in 100. The weights of yolk, albumen, and shell plus membranes were estimated. While, albumen height, yolk height and
Table (1): The composition and calculated analysis of the experimental diets fed to Silver Montazah laying hens.

| Ingredient                  | 1     | 2     | 3     | 4     | 5     | 6     |
|-----------------------------|-------|-------|-------|-------|-------|-------|
| Yellow corn                 | 65.50 | 62.50 | 57.40 | 67.35 | 62.70 | 59.30 |
| Soybean meal 44% CP         | 13.0  | 20.50 | 25.40 | 14.81 | 20.50 | 25.32 |
| Corn gluten meal 62% CP     | 2.90  | 2.50  | 3.00  | 2.50  | 3.00  | 3.70  |
| Wheat bran                  | 8.23  | 4.52  | 3.60  | 4.00  | 2.237 | 0.00  |
| Limestone                   | 7.90  | 7.72  | 7.70  | 7.50  | 7.50  | 7.60  |
| Di-calcium phosphate        | 1.60  | 1.60  | 1.60  | 1.60  | 1.60  | 1.60  |
| Soya oil                    | 0.00  | 0.00  | 0.70  | 1.35  | 1.8   | 1.88  |
| Sodium chloride             | 0.30  | 0.30  | 0.30  | 0.30  | 0.30  | 0.30  |
| *Vit. & Min. Premix         | 0.30  | 0.30  | 0.30  | 0.30  | 0.30  | 0.30  |
| Lysine (Lysine HCl)         | 0.15  | 0.00  | 0.00  | 0.11  | 0.00  | 0.00  |
| Methionine                  | 0.12  | 0.06  | 0.00  | 0.13  | 0.063 | 0.00  |
| Total                       | 100   | 100   | 100   | 100   | 100   | 100   |

**Calculated analysis

| Ingredient                  |       |       |       |       |       |       |
|-----------------------------|-------|-------|-------|-------|-------|-------|
| Crude Protein %             | 13.84 | 16.04 | 17.9  | 13.98 | 16.00 | 17.92 |
| ME (kcal/kg)                | 2703  | 2701  | 2703  | 2850  | 2849  | 2845  |
| Crude fiber %               | 3.45  | 3.52  | 3.62  | 3.16  | 3.26  | 3.28  |
| Ether Extract%              | 3.18  | 2.918 | 3.42  | 4.35  | 4.59  | 4.47  |
| Calcium %                   | 3.449 | 3.40  | 3.40  | 3.31  | 3.31  | 3.25  |
| Non-phytate P.%             | 0.422 | 0.426 | 0.432 | 0.423 | 0.419 | 0.423 |
| Lysine, %                   | 0.735 | 0.806 | 0.938 | 0.733 | 0.798 | 0.926 |
| Methionine, %               | 0.398 | 0.368 | 0.338 | 0.408 | 0.376 | 0.346 |
| Meth. & Cyst.               | 0.644 | 0.645 | 0.644 | 0.652 | 0.651 | 0.650 |
| Feed cost L.E/kg            | 4.616 | 4.747 | 4.974 | 4.804 | 5.004 | 5.212 |

Economic efficiency of feed (EEF) was calculated according to:

$$ EEF = \frac{\text{(Sale price of change BW + Price hatch chicks)} - \text{Total feed cost} \times 100}{\text{Total feed cost}} $$
Statistical Analyses:

A factorial arrangement (2 x 3) in a completely randomized design was performed; two dietary ME levels (2700 and 2850 kcal/kg) and three protein levels (14, 16 and 18%). The data were analyzed according to General Liner Model (GLM) procedure by means of two-way analysis of variance using SPSS computer program (SPSS, 2011). The following mathematical model was used:

\[ Y_{ijk} = \mu + ME_i + P_j + (ME \times P)_{ij} + e_{ijk}. \]

Where \(Y_{ijk}\) = An observation, \( \mu \) = Overall mean, \( ME_i \) = The metabolizable energy effect (i= 1,2), \( P_j \) = The protein level effect (j=1,2 and 3), \( (ME \times P)_{ij}\) = The interaction effect between energy and protein levels and \( e_{ijk} \) = The random residual error.

Duncan’s multiple range test was used to determine the significant differences among means of different variables (Duncan, 1955).

RESULTS AND DISCUSSION

Productive performance:

Body weight and feed intake:

Increasing energy level from 2700 to 2850 kcal/kg diet resulted in significant improvement (P≤0.01) in FBW and BWC. On the other side, daily feed intake, daily protein intake (DFI) and daily energy intake exhibited significantly increased in response to feeding on low-energy diets as shown in Table (2). These results are agreement with findings by Nofal et al. (2018), who found that hens fed on the diet containing of 2800 kcal ME/kg displayed significantly (P≤0.01) increased in FBW and body weight gain than those fed on the diet 2600 kcal ME/kg. In addition, hens fed the low-energy diet consumed more feed than those fed on the high-energy diet. In the same trend, Omara et al. (2009) indicated that body weight gain for hens, were significantly increased because of feeding on the energy-sufficient diets, then that of hens fed on lower energy-diets. This may be attributed to the fact decreasing available energy for fat deposition with lowering dietary ME levels resulting in reducing body weight gain.

Although there were no significant differences in FBW of hens fed 16% CP-diets than hens fed on 14 or 18%-CP diets however, heavier body weight and BWC were recorded by hens fed 18% CP-diet than those fed on 14% CP-diets. Daily protein intake was significantly (P≤0.01) increased of hens fed 18%-CP than those fed 14 or 16% CP-diet. Hens fed on 14 or 16% CP-diets fortified with methionine consumed more feed and daily energy intake was increased compared with those fed 18% CP-diet. Our results of the present study are agree with the findings of Yakout (2010) who found that reduction of dietary protein to 13% with supplementation of Met, Lys, Trp and Thr resulted in a significant decrease in BW and protein intake Compared with other levels (15, 15.5, 17.5% CP). Also, Kumari et al. (2016) found that body weight was increased with increasing protein levels in the hen diet. Van Emous et al. (2015) Latshaw and Zhao (2011), Gheisar et al. (2011), Keshavarz and Jackson (1992) and Wu et al. (2007) indicated that birds fed low CP diet had a higher feed intake vs. high-CP diet which might be due to an amino acid appetite. Conversely Tenesa et al. (2016) who found there no significant differences in live body weight when hens fed low crude protein diets (17 and 16.5% CP) supplemented with methionine, lysine and threonine than those fed on 17.5% CP. Hassan et al. (2000) and Yakout (2000), showed that laying hens fed different CP levels revealed insignificant differences in body weight.

Hens fed diet containing 18% CP and 2850 kcal/kg diet achieved highest FBW and BWC and lowest DFI compared with other treatment groups. In contrast hens received diet containing 14% CP and 2700 kcal/kg diet recorded the lowest FBW, BWC than other treatment groups. It will be noticed that FBW of hens fed diets 14 or 16% CP fortified with methionine were similar in FBW to those fed 18% CP at the high-energy level but hens fed on diet 14% CP and low-energy level resulted in lighter FBW compared with other treatment groups. This enhanced if dietary metabolizable energy needs to be increased, then essential amino acids also should be increased. Where efficiency of utilization of amino acid in laying hens is affected by factors such as dietary energy concentration, amino acid balance in the diet, age of the birds, rate of lay and the proportions of the egg components.
Table (2): Effect of dietary energy and protein levels fortified with methionine and their interactions on live body weight, daily feed intake, daily protein intake and daily energy intake of Silver Montazah laying hens.

| Treatment | Initial BW (g) | Final BW (g) | Chang in BW (g) | Daily feed intake (g)/h | Daily protein intake (g)/h | Daily energy intake (kcal)/h |
|-----------|----------------|--------------|-----------------|--------------------------|----------------------------|-----------------------------|
| Energy levels (E) | | | | | | |
| E 1 2700 kcal/kg | 1452.20 | 1555.13 | 102.93 | 108.69 | 17.44 | 293.75 |
| ±5.37 | ±5.82b | ±3.44b | ±0.54a | ±0.22a | ±1.47a |
| E 2 2850 kcal/kg | 1454.49 | 1588.20 | 135.71 | 101.29 | 16.22 | 288.98 |
| ±6.10 | ±5.94a | ±2.87a | ±0.47b | ±0.22b | ±1.35b |
| Significance level | NS | ** | * | NS | NS | NS |
| Protein levels (P) | | | | | | |
| P 1 14% | 1454.43 | 1557.63 | 103.20 | 106.87 | 15.02 | 296.57 |
| ±5.80 | ±6.92b | ±5.20b | ±0.79a | ±0.12c | ±1.44a |
| P 2 16% | 1451.60 | 1574.10 | 122.50 | 105.97 | 17.04 | 294.16 |
| ±6.29 | ±6.85ab | ±4.19a | ±1.01a | ±0.17b | ±1.56a |
| P 3 18% | 1451.00 | 1583.27 | 132.27 | 102.13 | 18.43 | 283.37 |
| ±8.76 | ±8.89ab | ±6.19a | ±0.71b | ±0.13a | ±1.32ab |
| Significance level | NS | ** | ** | NS | NS | NS |
| Interactions | E1 X P1 | 1455.40 | 1534.87 | 79.47 | 110.13 | 15.51 | 297.36 |
| ±7.62 | ±7.30c | ±4.65c | ±0.52a | ±0.07d | ±1.39a |
| E1 X P2 | 1449.00 | 1560.07 | 111.07 | 100.00 | 12.88 | 300.26 |
| ±7.44 | ±7.31bc | ±2.06d | ±0.53a | ±0.08b | ±1.42a |
| E1 X P3 | 1452.20 | 1570.47 | 118.27 | 104.93 | 18.93 | 283.63 |
| ±12.52 | ±12.83ab | ±5.00cd | ±0.83b | ±0.15a | ±2.25ab |
| E2 X P1 | 1453.47 | 1580.40 | 126.93 | 103.60 | 14.52 | 295.78 |
| ±9.01 | ±8.44ab | ±4.15bc | ±0.90b | ±0.13c | ±2.57a |
| E2 X P2 | 1454.20 | 1588.13 | 133.93 | 100.93 | 16.20 | 288.06 |
| ±10.37 | ±10.63ab | ±5.48b | ±0.58c | ±0.10c | ±1.66b |
| E2 X P3 | 1449.80 | 1596.07 | 146.27 | 99.33 | 17.93 | 283.10 |
| ±12.68 | ±11.80a | ±4.09a | ±0.51c | ±0.10b | ±1.46d |
| Significance level | NS | ** | * | NS | NS | NS |

*ab....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.

Feed conversion (FCR):

Data presented in Table (3) showed that there were significant differences in daily methionine intake, feed conversion ratio (FCR), protein conversion ratio (PER) and energy conversion ratio (EER) as affected by dietary ME and protein levels and their interaction. Increasing energy or protein levels in the diet resulted in decreasing in daily methionine intake and significant improvement in EER and FCR than other low levels of energy and protein. On the other side increasing in daily methionine intake of hens fed 16% or 14% CP-diet which consumed more feed than that fed high CP-diet. Furthermore, in addition EER and FCR were significant (P<0.01) improved by increasing energy or protein levels resulted in gradually improvements in EER and FCR but PER was declined by increasing protein level in the diet. Results of interaction between studied factors revealed significant differences (P<0.01) whereas EER and FCR were improved with high energy level and any protein levels. On the other hand FCR of hens fed 14% CP and high energy diet were equivalent to those fed 18% CP and low energy diet while the better FCR was obtained by hens fed high-energy and high-protein diets compared with other treatments. Our results herein agree with those results reported by Nofal et al. (2018) showed that feed conversion of laying hens was significantly (P<0.01) improved with increasing energy level in the diets. In addition, some of researchers Marney et al. (2009) noticed that increasing the nutrient density of diets resulted in significantly (P<0.05) improvement in feed conversion. (Grobis et al., 1999, Harms et al., 2000, Bryant et al., 2005, and Wu et al., 2005) found...
Table (3): Effect of dietary energy and protein levels fortified with methionine and their interactions on daily methionine intake, protein efficiency ratio (PER), energy efficiency ratio (EER) and feed conversion (FCR) of Silver Montazah laying hens.

| Treatment                        | Daily Meth. intake g/h | PER     | EER     | FCR     |
|----------------------------------|------------------------|---------|---------|---------|
| **Energy levels (E)**            |                        |         |         |         |
| E 1 2700 kcal/kg                 | 0.400±0.01\textsuperscript{a} | 0.559±0.01\textsuperscript{a} | 9.45±0.09\textsuperscript{a} | 3.50±0.03\textsuperscript{a} |
| E 2 2850 kcal/kg                 | 0.381±0.01\textsuperscript{b} | 0.499±0.01\textsuperscript{b} | 8.91±0.08\textsuperscript{b} | 3.12±0.03\textsuperscript{b} |
| **Protein levels (P)**           |                        |         |         |         |
| P 1 14%                          | 0.431±0.00\textsuperscript{a} | 0.488±0.01\textsuperscript{c} | 9.64±0.10\textsuperscript{a} | 3.48±0.05\textsuperscript{a} |
| P 2 16%                          | 0.394±0.00\textsuperscript{b} | 0.531±0.01\textsuperscript{b} | 9.16±0.10\textsuperscript{b} | 3.30±0.05\textsuperscript{b} |
| P 3 18%                          | 0.349±0.00\textsuperscript{c} | 0.568±0.01\textsuperscript{c} | 8.73±0.07\textsuperscript{c} | 3.15±0.03\textsuperscript{c} |
| **Interactions**                 |                        |         |         |         |
| E1 X P1                          | 0.438±0.04\textsuperscript{a} | 0.517±0.01\textsuperscript{c} | 9.91±0.12\textsuperscript{a} | 3.67±0.05\textsuperscript{a} |
| E1 X P2                          | 0.408±0.04\textsuperscript{b} | 0.570±0.01\textsuperscript{a} | 9.57±0.11\textsuperscript{b} | 3.54±0.05\textsuperscript{b} |
| E1 X P3                          | 0.355±0.04\textsuperscript{c} | 0.591±0.01\textsuperscript{c} | 8.86±0.09\textsuperscript{c} | 3.28±0.03\textsuperscript{c} |
| E2 X P1                          | 0.423±0.00\textsuperscript{a} | 0.460±0.01\textsuperscript{c} | 9.36±0.12\textsuperscript{a} | 3.28±0.04\textsuperscript{a} |
| E2 X P2                          | 0.380±0.00\textsuperscript{b} | 0.492±0.004\textsuperscript{c} | 8.75±0.08\textsuperscript{c} | 3.07±0.03\textsuperscript{c} |
| E2 X P3                          | 0.344±0.00\textsuperscript{c} | 0.545±0.01\textsuperscript{b} | 8.60±0.10\textsuperscript{c} | 3.03±0.03\textsuperscript{c} |

\* For each of the main effects, means in the same column bearing different superscripts differ significantly **, \(P<0.01\).
higher egg weight and egg mass versus those received diets with 150 and 130 g CP/kg. In addition, hen fed diets with 130 g CP/kg decreased feed intake and worsened feed conversion ratio per kg of eggs. Silva et al. (2010) reported that reducing dietary CP from 180 to 120 g/kg diet resulted in linear decrease in egg weight and egg mass value even providing layer requirements for all essential amino acids. Rama Rao and Tirupathi Reddy (2016) found that egg production, egg mass and were increased in white leghorns as dietary energy and protein increased. On the other side Kumari et al. (2016) observed that EP, FI, EW were not influenced by different protein levels in WLH layers’ diet from 25–44 weeks of age Similarly, Mousavi et al. (2013) observed that EP was not affected by the reduction in dietary protein level from (18.5–15.5%), without any alteration in digestible total sulfur amino acids and threonine: lysine ratio.

The calculated analysis of the experimental diets showed that in order to reach a constant level of SAA, this requires an increase in the level of methionine in low-protein diets whose lysine level is low due to reduction in soybean meal amount which has caused a disturbance in the amino acid balance and hence the balance of essential amino acids, especially in terms of total sulfur amino acids and lysine which are two first limiting amino acids is highly important when low-protein diets are fed. On the other hand, this strain seems unable to compensate for low dietary ME and CP content by increasing its feed intake sufficiently to meet energy and protein/or other nutrient (amino acids) requirements to gave best performance.

**Egg quality and reproductive parameters:**

Results revealed that there no significant variations (P≤0.05) were observed in egg quality, fertility percentage and chick weight due to feeding on different energy and protein levels as shown in Tables (5 and 6). These results are agreement with Tenesa et al. (2016) who fed Hisex brown hens: 17.5% CP (control); 17.5%, 17% and 16.5% CP supplemented with amino acid and they found no significant differences (P>0.05) in Haugh units, yolk and albumen weight percentage, eggshell weight and thickness among the treatment groups. Similarly, Tesfaye et al. (2019) noticed that no significant differences in egg quality, fertility and hatchability when hens fed on diets different protein-energy levels (16-2750, 16.5-2800, 17-2900 and 16% CP-2700 ME kcal/kg diet). In the same trend, Hussein et al. (2010) reported that there were not significant differences in reproductive traits and egg quality of Sinai laying hens due to the experimental CP and ME levels. Yakout (2010) observed no significant differences by inclusion protein levels 17, 17.5, 15 and 13% CP supplemented with amino acid in laying diets on egg quality as well Ding et al. (2016) observed
Table (5): Effect dietary energy and protein levels fortified with methionine and their interactions on fertility and hatchability of Montazah laying hens.

| Treatment | Fertility % | Hatchability of fertile egg % | Hatchability of total egg % | Chick weight (g) |
|-----------|-------------|-------------------------------|-----------------------------|-----------------|
| E1 2700 kcal/kg | 86.59±0.33 | 88.84±0.56 | 76.91±0.40 | 33.30±0.37 |
| E2 2850 kcal/kg | 87.70±0.50 | 89.27±0.68 | 78.28±0.54 | 34.17±0.38 |
| Significance level | NS | NS | NS | NS |

Protein levels (P)

| P 1 14% | 86.86±0.67 | 88.84±0.86 | 77.14±0.49 | 33.50±0.45 |
| P 2 16% | 86.98±0.61 | 88.90±0.91 | 77.31±0.73 | 33.95±0.41 |
| P 3 18% | 87.60±0.40 | 89.43±0.52 | 78.34±0.64 | 33.75±0.55 |
| Significance level | NS | NS | NS | NS |

Interactions

| E1 X P1 | 86.31±0.76 | 88.57±1.57 | 76.43±0.42 | 33.30±0.67 |
| E1 X P2 | 86.46±0.75 | 88.66±0.35 | 76.65±0.48 | 33.50±0.60 |
| E1 X P3 | 86.98±0.17 | 89.29±1.03 | 77.66±0.87 | 33.10±0.72 |
| E2 X P1 | 87.40±1.19 | 89.10±1.10 | 77.85±0.40 | 33.70±0.63 |
| E2 X P2 | 87.50±1.02 | 89.14±1.99 | 77.97±1.42 | 34.40±0.54 |
| E2 X P3 | 88.21±0.61 | 89.57±0.53 | 79.01±0.92 | 34.40±0.82 |
| Significance level | NS | NS | NS | NS |

All means in the same column were not significantly.

Table (6): Means of egg quality measurements as affected by dietary energy levels and protein levels fortified methionine and their interaction in Montazah laying hens.

| Treatment | Egg shape % | Egg component | Shell thickness (mm) | Hough Unit | Yolk index % | Specific gravity | ESA |
|-----------|-------------|---------------|---------------------|------------|--------------|-----------------|-----|
| Energy levels (E) | | | | | | | |
| E1 2700 kcal/kg | 75.92 | 54.68 | 30.91 | 14.50 | 34.33 | 81.41 | 46.61 | 1.111 | 64.17 |
| kcal/kg | ±0.81 | ±0.72 | ±0.46 | ±0.77 | ±0.50 | ±1.22 | ±1.05 | ±0.00 | ±0.93 |
| E2 2850 kcal/kg | 77.59 | 54.45 | 30.99 | 14.41 | 34.56 | 80.56 | 48.39 | 1.109 | 63.61 |
| kcal/kg | ±1.21 | ±0.77 | ±0.63 | ±0.50 | ±0.34 | ±2.01 | ±0.46 | ±0.00 | ±1.02 |
| Significance level | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Protein levels (P) | | | | | | | |
| P 1 14% | 77.90 | 54.23 | 30.57 | 15.19 | 34.67 | 81.41 | 49.07 | 1.110 | 64.74 |
| kcal/kg | ±1.84 | ±0.78 | ±1.95 | ±0.91 | ±0.67 | ±2.97 | ±0.62 | ±0.00 | ±0.59 |
| P 2 16% | 75.87 | 54.97 | 30.89 | 14.14 | 34.00 | 81.53 | 47.07 | 1.109 | 65.12 |
| kcal/kg | ±0.58 | ±1.15 | ±0.97 | ±0.30 | ±0.37 | ±1.86 | ±0.35 | ±0.00 | ±1.27 |
| P 3 18% | 76.51 | 54.49 | 31.39 | 14.03 | 34.67 | 80.00 | 46.35 | 1.110 | 61.82 |
| kcal/kg | ±1.60 | ±0.82 | ±0.66 | ±0.97 | ±0.49 | ±0.91 | ±1.53 | ±0.01 | ±1.16 |
| Significance level | NS | NS | NS | NS | NS | NS | NS | NS | NS |

All means in the same column were not significantly.
that there was no significant interaction between ME (2650 and 2750 kcal/kg) and CP (14.5, 15 and
15.5%) on egg quality and discrepancy with Zeweil et al. (2011) who showed that increasing CP level
significantly decreased hatched percentage of chicks of Baheij hens.

**Blood parameters:**

The effects of energy and dietary protein levels supplemented with methionine and their interactions on
some blood parameters are summarized in Table (7). Results based on effects of energy levels showed that
there were not significant differences in most blood parameters; total protein, albumin, globulin AST, ALT
and glucose in response to feeding on low-energy diet than that high-energy diet but cholesterol level was
significantly reduced (P≤0.01). Increasing protein level caused to significant differences (P≤0.01) in values
of AST and ALT whereas hens received diet containing 18% CP displayed significant increasing in ALT in
blood plasma than that fed 14% CP, while other parameters were not affected.

Interactions between studied factors are presented in Table (7). Statistical analysis revealed significant
differences in AST, ALT and cholesterol in blood plasma; however, there were not significant differences in

**Table (7): Effect of dietary energy levels and protein fortified with methionine and their interactions
on some blood parameters of Montazah laying hens.**

| Treatment | Total protein g/dl | Albumin g/dl | Globulin g/dl | AST U/L | ALT (U/L) | Cholesterol mg/dl | Glucose mg/dl |
|-----------|-------------------|--------------|---------------|---------|-----------|-------------------|---------------|
| E1 2700 kcal/kg | 4.40 ±0.05 | 2.58 ±0.04 | 1.82 ±0.05 | 20.22 ±1.48 | 26.67 ±0.88 | 115.11 ±0.53 | 248.56 ±1.04 |
| E2 2850 kcal/kg | 4.52 ±0.06 | 2.64 ±0.06 | 1.88 ±0.07 | 17.78 ±0.70 | 26.67 ±0.65 | 121.56 ±1.45 | 249.78 ±0.89 |
| Significant level | NS | NS | NS | NS | NS | ** | NS |
| P1 14% | 4.43 ±0.05 | 2.63 ±0.04 | 1.80 ±0.04 | 15.67 ±0.67b | 25.50 ±0.76b | 116.67 ±1.33 | 248.00 ±0.73 |
| P2 16% | 4.47 ±0.08 | 2.68 ±0.05 | 1.78 ±0.07 | 22.00 ±1.48a | 25.33 ±0.42b | 117.67 ±0.84 | 248.83 ±1.47 |
| P3 18% | 4.48 ±0.08 | 2.52 ±0.07 | 1.97 ±0.10 | 19.33 ±0.84a | 29.17 ±1.20 | 120.50 ±1.47 | 250.67 ±1.47 |
| Significant level | NS | NS | NS | ** | ** | NS | NS |

| Interactions | Total protein g/dl | Albumin g/dl | Globulin g/dl | AST U/L | ALT (U/L) | Cholesterol mg/dl | Glucose mg/dl |
|--------------|-------------------|--------------|---------------|---------|-----------|-------------------|---------------|
| E1 X P1 | 4.40 ±0.06 | 2.60 ±0.06 | 1.80 ±0.12 | 15.67 ±1.20c | 26.67 ±0.88c | 114.67 ±1.20c | 248.67 ±0.88 |
| E1 X P2 | 4.43 ±0.09 | 2.67 ±0.09 | 1.76 ±0.03 | 24.67 ±1.76a | 26.00 ±0.58cd | 115.33 ±0.88bc | 246.67 ±2.19 |
| E1 X P3 | 4.37 ±0.12 | 2.47 ±0.03 | 1.90 ±1.33b | 20.33 ±0.88a | 29.67 ±0.88b | 115.33 ±0.88bc | 250.33 ±2.03 |
| E2 X P1 | 4.47 ±0.09 | 2.67 ±0.07 | 1.80 ±0.06 | 15.67 ±0.88c | 26.67 ±0.88bc | 118.67 ±1.86bc | 247.33 ±1.20 |
| E2 X P2 | 4.50 ±0.15 | 2.70 ±0.07 | 1.80 ±0.06 | 19.33 ±0.88bc | 24.67 ±0.33cd | 120.00 ±1.16b | 251.00 ±1.16 |
| E2 X P3 | 4.60 ±0.06 | 2.57 ±0.15 | 2.03 ±0.03 | 18.33 ±0.88bc | 28.67 ±0.33ab | 126.00 ±2.31a | 251.00 ±1.53 |
| Significant level | NS | NS | NS | ** | ** | NS | NS |

*....For each of the main effects, means in the same column bearing different superscripts differ significantly NS = not significant **: P< 0.01).
AST value among hens received diets different protein levels and high energy level but the lowest value of AST was recorded by hens fed low-protein diet with any energy levels compared with other treatment groups. In contrast the highest value of cholesterol was recorded by hens fed low-protein diet with any energy levels compared with other treatment groups. In contrast the highest value of cholesterol was recorded by hens fed diet containing 18% CP and 2850 kcal/kg diet. These results agreement with the findings of Nofal et al. (2018), who observed increasing cholesterol in blood plasma as a result of feeding hens on high-energy diet (2800 kcal/kg diet) compared with the low-energy diets (2600 kcal/kg diet) but plasma levels of albumin, glucose and activity of AST were not affected. Similarly Kout El-kloub et al. (2005) illustrated that blood parameters were not affected by different protein and energy levels in laying hens and disagreement with Zeweil et al. (2011) who reported that plasma total protein and globulin concentrations of laying hens fed diet containing 16% CP more than those fed 12 or 14% CP-diet.

**Economic efficiency of feed (EEF):**

In Table (8) it can be postulated that feed intake is considered one of the important factors to calculate EE, decreasing feed intake in response to fed different protein levels and high-energy diets resulted in decreased in feed cost (55.47 LE, 56.57 LE and 57.99 LE) than those the same level of protein and low-energy diets (56.94 LE, 59.01LE and 58.46 LE) and with raising of Price of fertile eggs/hen and net return which reflected in higher in EEF. Although hens fed 16% CP-diet achieved the highest of total price of egg fertile, total return, net return and EEF however, hens received 14% CP and high-energy diets was similar in total price of egg fertile, total return, net return and EEF than that fed 16 and 18% CP at the same energy level compared with other treatment groups.

**Table (8): Effect of dietary energy levels and protein levels fortified with methionine and their interactions on economic efficiency of feed (EEF) of Silver Montazah laying hens.**

| Treatment  | Total feed intake of hen(kg) | Price of feed cost /hen L. E | Return BWG L. E | Total Price of fertile eggs/hen LE | Total return L. E | Net return L. E | Relative EE% |
|-----------|-----------------------------|-----------------------------|-----------------|----------------------------------|-----------------|----------------|-------------|
| E1 X P1   | 12.33 ±0.06                 | 56.94 ±0.27                 | 2.78 ±0.16      | 152.55 ±1.88                    | 155.33 ±1.86    | 98.39 ±1.84    | 172.86      |
| E1 X P2   | 12.43 ±0.06                 | 59.01 ±0.28                 | 3.89 ±0.07      | 156.30 ±1.50                    | 160.19 ±1.54    | 101.17 ±1.55   | 171.51      |
| E1 X P3   | 11.75 ±0.09                 | 58.46 ±0.46                 | 4.14 ±0.18      | 158.85 ±0.48                    | 162.99 ±0.53    | 104.53 ±0.81   | 179.10      |
| E2 X P1   | 11.60 ±0.10                 | 55.74 ±0.48                 | 4.44 ±0.15      | 157.50 ±1.10                    | 161.94 ±1.10    | 106.20 ±1.32   | 190.90      |
| E2 X P2   | 11.30 ±0.07                 | 56.57 ±0.33                 | 4.69 ±0.19      | 160.95 ±0.65                    | 165.64 ±0.73    | 109.07 ±0.87   | 192.98      |
| E3 X P3   | 11.13 ±0.06                 | 57.99 ±0.30                 | 5.12 ±0.14      | 160.20 ±1.15                    | 165.32 ±1.33    | 107.33 ±1.33   | 185.29      |

1- Total feed cost /hen L. E= Feed intake x price of kg feed.
2- Return BWG= BWG X price of kg BW at time of experiment = 35 L.E.
3- Total price of fertile eggs /hen L. E= total No. of fertile egg /hen x price of fertile egg at time of experiment=225Pt.
4- Total return = Total price of fertile eggs /hen L. E+ Return BWG.
5- Net return = Total return - Price of feed cost.
6- Relative economic efficiency = Net return / Price of feed cost*100.
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