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PRODUCTIVE PERFORMANCE OF SILVER MONTAZH LAYING HENS FED DIETS CONTAINING DIFFERENT LEVELS OF PROTEIN AND ENERGY

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SUMMARY

The energy and protein content of the diet play an important role in adjusting the bird's consumption to meet its needs for growth and to begin producing eggs. The purpose of this study was to look into how energy and protein levels affected laying performance, egg quality, fertility, hatchability rate and some blood parameters. A total of 144 Silver Montazah laying hens 24-weeks-old were randomly divided into six treatments in a 2 × 3 factorial design using two metabolizable energy levels (2700 and 2850 Kcal ME/kg) and three protein levels: low (14%), medium (16%), and high (18%). The birds were kept individually in cages, with 24 hens for each treatment. The results can be summarized as follows: Birds fed on higher energy content exhibited significantly ($P \leq 0.01$) increased in final body weight (FBW), change in body weight (CBW), feed conversion ratio (FCR), egg production (EP) parameters and cholesterol level compared to low-energy diets. However, hens provided with low-energy diets had an increased significant ($P \leq 0.1$) in daily feed intake (DFI), daily protein intake (DPI), protein efficiency ratio (PER), and metabolizable energy efficiency (MEE). Birds fed 18%-protein diets exhibited significant increases in FBW, CBW, DPI, PER, FCR, EP, MEE, and alanine amino transferees than those fed on 14% -protein diets. Birds fed 16 or 18% protein with a high energy level showed improvements in FBW, CBW, FCR, and EP. In addition, blood cholesterol levels significantly increased compared to other treatments. Furthermore, hens received 16% -protein diet with the low-energy level scored the greatest values in aspartate transaminase, but the same energy level with 18% protein resulted in a significant ($P \leq 0.01$) increase in ALT compared to other treatments. Hens fed a diet of 16% protein with a 2850 Kcal/kg diet achieved the highest economic efficiency compared to other groups.

From an economic point of view, it is clear that a diet of 16% protein and 2850 Kcal/Kg is the most optimal for Silver Montazah laying hens to maximize productive performance during the 24 -to -39 -week study period.

Keywords: *Crude protein levels, metabolizable energy, laying hens, productive, reproductive performance and blood.*

INTRODUCTION

Raising poultry can be a viable way to improve the economic standing of the rural populace using locally grown chicken varieties that require fewer inputs for nutrition, management and improved performance, as well as increasing the availability of poultry products like eggs and meat. Approximately 60–70% of the production cost goes toward feed, making it one of the most costly components of poultry production. Most of the cost in the diet is related to protein as well as energy. The diet's energy and protein content must be adjusted in order to be sure that hens get enough nutrients to deal with growth and the onset of egg production (Bain *et al*., 2016). Protein is one of the most essential nutrients that affect growth, feed utilization, and production efficiency (NRC, 1994). Inversely, excessive levels of crude protein (CP) in the diet can cause increased nitrogen excretion and odor emission because CP that has not been digested and absorbed as well as uric acid, which is the final product of protein metabolism, are simultaneously excreted in feces (Chalova *et al*., 2016). However, it should be remembered that when CP levels in poultry feed are reduced, the harmony between adequate nutritional levels and production performance needs to be taken into account.

Energy is a vital nutritional factor that affects a bird's performance, as it is for all species (NRC, 1994). A bird's energy requirements vary depending on its breed and age (Classen, 2017), as well as body weight, egg size, production phase, and room temperature (Coon, 2002). Morris (2004) stated that when a diet has a low energy density, the bird will increase its intake of feed until it meets its energy needs. Harms *et al*. (2000) stated that laying hens' energy consumption efficiency is dependent on a few specific genetic traits. According to Faria and Santos (2005), taking into account the metabolic weight and daily production of eggs, the energy requirement of laying hens is linearly related to body weight. However, energy must also be taken into account, as balanced protein is only one of the two major components of the nutritional package.

Dietary energy levels can have significant effects on production costs because raising energy levels with the addition of fat may significantly decrease feed intake (FI), increase egg weight (EW) and improve feed conversion (Adeola 2001; Harms *et al*., 2000 and Wu *et al*., 2005). It has been demonstrated that adding poultry oil to a diet may significantly affect the percentage of egg components (Wu *et al*., 2007). According to Grobas *et al.* (1999), feed consumption was reduced by 5.0% when the apparent metabolizable energy content of the diet increased from 2,680 to 2,810 Kcal/kg. However, egg production (EP) and egg mass (EM) remained unaffected.

This study aims to investigate the nutritional value of the number of calories per unit of CP in the diet of laying hens, which is crucial to reduce ingredient costs and maintain high protein-energy efficiency in the diet with the aim of achieving optimal growth and productive performance.

MATERIALS AND METHODS

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

Bird's management and experimental design:

One hundred forty-four Silver Montazah laying hens, aged 24 weeks, were randomly chosen and placed into six groups based on body weight similarity with no statistical differences. There were 24 birds in each group. Every experimental birds were kept in individual layer cages with the same management and hygiene conditions. Experimental treatments involved two metabolizable energy levels (2700 and 2850 Kcal ME/kg) and three levels of (14, 16, and 18% CP) through an experimental period from 24 to 39 weeks of age in a 2 x 3 factorial arrangement as presented in Table 1. The purpose of the proposed dietary energy and protein levels for Silver Montazah laying hens was to identify the optimum dietary energy and protein levels that would maximize their reproductive and productive performance. Throughout the experiment, the hens were given free access to fresh water and fed *ad libitum*, with a photoperiod of 16 hours of light and 8 hours of darkness per day.

Productive performance:

At the beginning and end of the experimental period, the live body weight change was recorded and taking the difference between the initial and final live body weights of the hens to calculate the change in body weight, while FI, egg number and EW were recorded weekly for each hen. The EP rate was calculated during the whole experimental period. The number of hen-day eggs produced was multiplied by the EW to calculate the EM. Feed conversion ratio (FCR) was computed as the germ of FI / hen / day divided by the gram of EM produced / hen / day. In addition, the metabolizable energy efficiency ratio (MEE) (kcal ME intake/g EM) and protein efficiency ratio (PER) as (g CP intake/g EM) were computed.

Egg quality measurements:

To estimate egg quality, thirty freshly laid eggs were randomly selected at 30, 31, and 32 weeks of age from each treatment to evaluate both external and internal indices of egg quality. Additionally, the weight of each egg was measured and the widths and lengths were recorded to determine the egg shape index, which was computed by dividing the egg length by the egg width × 100. After that, they were cracked open onto a level, smooth surface in order to measure the albumen height, yolk height, and yolk diameter. Each egg's shell and yolk were weighted while albumen weight was calculated, and a standard micrometer was used to measure the thickness of the shell. The yolk index was computed by dividing the yolk diameter by the yolk height × 100. 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). The Haugh unit score for every egg was determined using the thick albumen height and EW, as described by Larbier and Leclercq (1994), as follows: Haugh units = $100 \log (H + 7.57 - 1.7w^{0.37})$. Where W is egg weight (g) and H is the thick albumen height (mm).

Table (1): The composition and calculated analysis of the experimental diets.

Dietary energy levels (Kcal ME/Kg)	**2700**			**2850**		
Dietary crude -protein levels (%)	**14**	**16**	**18**	**14**	**16**	**18**
Ingredients,%						
Yellow corn	62.35	62.00	57.60	63.60	62.60	59.30
Soy bean meal (44%)	18.30	18.00	25.40	19.20	20.50	25.00
Corn glutein 62%	0.00	4.00	3.00	0.00	3.00	4.00
Wheat bran	8.10	6.10	3.50	4.50	2.10	0.0
Limestone	7.75	7.70	7.70	7.70	7.70	7.60
Di-calcium phosphate	1.60	1.60	1.60	1.60	1.60	1.60
Sunflower oil	1.30	0.00	0.60	2.80	1.90	1.90
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.30
*Vit. & Min.	0.30	0.30	0.30	0.30	0.30	0.30
Total	100	100	100	100	100	100
**Calculated composition						
Crude protein %	14.62	16.63	18.48	14.56	16.53	18.52
ME (Kcal/kg)	2719	2707	2707	2869	2864	2863
Crude fiber	3.54	3.35	3.47	3.24	3.08	3.11
Ether extract	4.06	2.78	3.17	5.51	4.58	4.45
Calcium	3.37	3.38	3.83	3.35	3.37	3.34
Available phosphorus	0.40	0.40	0.41	0.40	0.40	0.41
Lysine	0.70	0.72	0.89	0.71	0.76	0.87
Methionine	0.24	0.30	0.31	0.24	0.29	0.32
Methionine + Cystine	0.50	0.59	0.63	0.50	0.57	0.63

**Premix at 0.30 of the diet supplies, the following per kg of the diets: Vit. A 10000 I.U, Vit.D3 2000 I. U, Vit. E 10 mg, Vit. K 1 mg, Vit.B1 1 mg, Vit.B2 5 mg, Vit.B6 1.5 mg, Vit.B12 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*

Fertility and hatchability:

A fixed volume of freshly collected semen from cockerels fed a diet containing 16% CP and a 2750 kcal/kg diet was used to artificially inseminate the hens in each experimental group. At 33, 34, and 35 weeks of age, three hatches had been done to calculate the percentages of hatchability and fertility of eggs.

Blood parameters:

On the last day of the trial, blood samples from each treatment were taken in heparinized test tubes. The plasma was then separated and kept at -20 °C for further analysis. Using readily available commercial kits, colorimetric techniques were used to measure the levels of total protein and albumin, cholesterol, glucose, and activity transaminases aspartate transaminase (AST) and alanine amino transferees (ALT) in plasma. Blood plasma globulin was calculated by subtracting the level of plasma albumin from the total protein content (Coles, 1974).

Economic efficiency:

The costs and returns were used for evaluating economic efficiency. The evaluation mainly taken into account the cost of the feed; all other costs, such as labor, medication, electricity, water, housing, etc., were assumed to be the same for each treatment. The amount of ingredients in each experimental diets and their pricing at the time of the experiment were used to estimate the costs of feeding. The revenue was calculated from the selling of the fertile eggs produced during the trial, along with the change in body weight, while net revenues were calculated from subtracting costs from total revenues. Economic efficiency was calculated as follows:

Economic efficiency of feeding = Net revenue / Total feed cost*100

Statistical Analysis:

The General Liner Model (GLM) procedure was used to statistically analyze the data through two-way analysis of variance using the SPSS computer program (SPSS, 2011). The model that was employed was this one:

$$Y_{ijk} = \mu + ME_i + P_j + MEP_{ij} + e_{ijk}.$$

Where: Y_{ijk} = observed traits; **μ:** overall mean; ME_i: the effect of metabolizable energy levels (i: 2700 and 2850 kcal/kg); P_j: the effect of protein levels (j: 14, 16 and 18%); MEP_{ij}: interaction between metabolizable energy levels and protein levels and e_{ijk}: random error. The significance of the differences between the experimental groups was tested using Duncan's multiple range test (1955).

RESULTS AND DISCUSION

Laying performance:

The findings presented in Tables 2 and 3 point out the effect of dietary energy levels, protein levels and their interactions on BW, CBW, DFI, DPI, PER, MEE and FCR of Silver Montazah laying hens. It was found that when dietary energy levels were increased to 2850 Kcal/kg FBW, CBW and FCR significantly improved (P< 0.01) in comparison to low energy levels. In contrast, birds fed low-energy diets displayed significantly higher increases in DFI, DPI, PER and MEE than those fed high-energy diets. There was a gradual significant improvement (P< 0.01) in FBW, CBW, DPI, and FCR in response to increasing protein levels from 14 to 18%, but FI was unaffected. However, as a result of increasing protein levels, DEI (P≤ 0.05) and MEE (P≤ 0.01) were significantly reduced.

Results showed that there was a significant difference in interaction between the levels of energy and protein. Birds given high-energy diets containing 18% protein had higher FBW, CBW, and the best FCR compared to other treatments, contrary birds fed low-energy with 14% protein diets had lower FBW, CBW the worst PER and FCR compared to other treatments. Simultaneously, birds fed low-energy-protein diets had the higher values of DFI and the worst MEE compared to high-energy-protein diets. While neither protein nor energy levels had an impact on DEI.

Egg production traits:

The effects of dietary energy, protein levels and their interactions on egg number, EW, daily EM and EP of Silver Montazah laying hens are presented in Table 4. Results pointed out that, in comparison to a diet with low energy content, raising the energy content to 2850 Kcal/kg led to significant increases in the egg number (P≤ 0.05), daily EM, EW (P≤ 0.01) and hen-day EP rate (P≤ 0.05). In the same trend, increasing dietary protein levels from 14 to 16 or 18% led to significant improvements (P≤ 0.01) in former traits compared to 14% protein level.

The results indicate that there was a statistically significant (P≤ 0.01) impact of the interaction between CP and energy levels. Hens received high-energy diets containing 18% protein had the highest values when compared to other groups in terms of egg number, EW, daily EM, and EP. However, birds fed a low-energy diet containing 14% protein recorded the worst values of egg number, EW and daily EM, with lower value of hen day egg production rate%. This result corroborates Alderey and Elweshahy (2019) and Alderey (2020), who demonstrated that laying hens fed high-energy diets showed significant improvements in their final BW, change in BW, and EP rate. Furthermore, the feed consumption, DPI, PER, and MEE were higher in birds fed low-energy diets. With an increase in dietary protein, there were gradual improvements observed in FBW, CBW, PER, FCR, and DPI. The lower FI resulting from the higher metabolizable energy content in the diet may be due to the fact that the birds were feeding to meet their energy requirements. Consequently, the birds stopped feeding when their energy requirements were met, thus allowing them to control their FI in accordance with the feed's energy content (Fonseca *et al*., 2021). Other studies that have shown similar decreases in FI as a result of higher dietary energy include ducks (Granghelli *et al.,* 2019) and laying hens (Kang *et al*., 2018 and Awad *et al*., 2022).

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

Treatments		Initial BW (g)	Final BW (g)	Chang in BW (g)	Daily feed intake (g)	Daily protein intake (g)	Daily energy intake (kcal)
Metabolizable energy levels (kcal/kg)							
2700		1451.87±7.58	1556.13±7.30^{b}	104.27±3.69^{b}	105.58±0.47^{a}	16.97±0.25^{a}	285.52±1.28
2850		1450.69±6.77	1595.11±6.43^{a}	144.42±4.36^{a}	100.44±0.38^{b}	16.12±0.22^{b}	286.47±1.08
Sig.		NS	**	**	**	*	NS
Crude protein levels% (CP%)							
14		1452.47±7.47	1560.57±7.85^{b}	108.10±5.48^{b}	104.10±0.63	14.69±0.09^{c}	289.30±1.38^{a}
16		1450.37±10.04	1573.03±9.10^{ab}	122.67±5.97^{b}	102.80±0.74	16.52±0.12^{b}	285.07±1.47^{b}
18		1451.00±8.75	1593.27±9.55^{a}	142.27±5.47^{a}	102.13±0.71	18.43±0.13^{a}	283.61±1.32^{c}
Sig.		NS	*	**	NS	**	*
Interactions							
ME (kcal/kg)	**CP%**						
2700	14	1450.00±10.56	1540.60±09.99^{c}	90.60±7.40^{e}	106.27±0.70^{a}	14.99±0.10^{e}	288.09±1.89
	16	1453.40±16.53	1557.33±14.34^{bc}	103.93±4.62^{de}	105.53±0.92^{a}	16.99±0.15^{c}	285.15±2.47
	18	1452.20±12.51	1570.47±12.83^{bc}	118.27±5.00^{cd}	104.93±0.83^{a}	18.93±0.15^{a}	283.42±2.24
2850	14	1454.93±11.22	1580.53±09.94^{b}	125.60±5.09^{bc}	101.93±0.71^{b}	14.39±0.10^{f}	290.61±2.02
	16	1447.33±11.96	1588.73±10.10^{ab}	141.40±8.74^{b}	100.07±0.60^{bc}	16.04±0.10^{d}	284.99±1.70
	18	1449.80±12.68	1616.07±11.80^{a}	166.27±4.09^{a}	99.63±0.51^{c}	17.93±0.09^{b}	283.80±1.47
Sig.		NS	**	**	**	**	NS

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

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

Treatments		PER	MEE	FCR
Metabolizable energy levels,kcal/kg (ME, kcal/kg)				
2700		$55.53±0.55^{a}$	$9.38±0.09^{a}$	$3.63±0.04^{a}$
2850		$50.60±0.54^{b}$	$9.03±0.09^{b}$	$3.23±0.04^{b}$
Sig.		**	**	**
Crude protein levels% (CP%)				
14		$50.00±0.58^{b}$	$9.84±0.09^{a}$	$3.76±0.05^{a}$
16		$52.37±0.66^{b}$	$9.03±0.08^{b}$	$3.38±0.06^{b}$
18		$56.82±0.60^{a}$	$8.74±0.07^{c}$	$3.16±0.03^{c}$
Sig.		**	**	**
Interactions				
ME (Kcal/kg)	**CP%**			
2700	14	$52.07±0.59^{c}$	$9.99±0.11^{a}$	$3.93±0.04^{a}$
	16	$55.40±0.60^{b}$	$9.30±0.10^{c}$	$3.68±0.04^{b}$
	18	$59.13±0.59^{a}$	$08.86±0.09^{d}$	$3.29±0.03^{d}$
2850	14	$47.93±0.67^{d}$	$9.68±0.14^{b}$	$3.57±0.05^{c}$
	16	$49.35±0.37^{d}$	$08.77±0.07^{d}$	$3.08±0.02^{e}$
	18	$54.51±0.63^{b}$	$08.63±0.10^{d}$	$3.02±0.03^{e}$
Sig.		**	**	**

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

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

Treatments		Egg number	Egg weight (g)	Daily egg mass (g)	hen-day egg production rate %
Metabolizable energy levels kcal/kg					
2700		$64.63±0.34^{b}$	$49.38±0.26^{b}$	$30.34±0.22^{b}$	$61.55±0.33^{b}$
2850		$65.73±0.33^{a}$	$50.81±0.22^{a}$	$31.95±0.22^{a}$	$62.60±0.30^{a}$
Sig.		*	**	**	*
Crude protein levels% (CP%)					
14		$63.31±0.39^{c}$	$48.86±0.27^{b}$	$29.46±0.21^{c}$	$60.30±0.37^{b}$
16		$65.75±0.31^{a}$	$50.39±0.31^{a}$	$31.57±0.26^{b}$	$62.62±0.30^{a}$
18		$66.47±0.30^{a}$	$51.04±0.25^{a}$	$32.40±0.17^{a}$	$63.30±0.29^{a}$
Sig.		**	**	**	**
Interactions					
ME (kcal/kg)	**CP%**				
2700	14	$62.69±0.56^{d}$	$48.21±0.33^{d}$	$28.78±0.26^{d}$	$59.70±0.53^{d}$
	16	$65.00±0.50^{bc}$	$49.43±0.41^{c}$	$29.69±0.23^{c}$	$61.90±0.48^{bc}$
	18	$66.19±0.33^{ab}$	$50.50±0.39^{b}$	$31.92±0.16^{b}$	$63.04±0.32^{ab}$
2850	14	$63.94±0.51^{cd}$	$49.50±0.36^{c}$	$30.14±0.24^{c}$	$60.89±0.49^{cd}$
	16	$66.50±0.27^{a}$	$51.36±0.27^{ab}$	$32.45±0.14^{ab}$	$63.33±0.26^{a}$
	18	$66.75±0.51^{a}$	$51.57±0.27^{a}$	$32.87±0.25^{a}$	$63.57±0.49^{a}$
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).*

Nofal *et al*. (2018) showed that hens fed a low-energy diet (2600 kcal/kg) had significantly lower FBW and body weight gain than hens fed a diet containing 2800 ME Kcal/kg. As well as hens fed on the diet with higher energy content consumed little feed and FCR was improved compared to low-energy content. But, daily EM was not significantly affected by decreasing dietary energy from 2800 to 2600 kcal/kg.

According to Hassan *et al*. (2020), in comparison to hens fed a diet containing 2600 kcal ME/kg, hens fed a diet containing 2800 kcal ME/kg exhibited significantly better feed efficiency as well as a significantly higher EP rate and EM. They added that, there was no significant difference in BW or EW between the two energy levels. Also, Omara *et al*. (2009) found that Lohmann Brown hens fed energy-sufficient diets observed a significantly increase in body weight gain compared to those fed low-energy diets. Low dietary energy levels may have decreased the amount of energy available for fat deposition, which in turn decreased weight gain. However, increasing energy up to 2800 kcal ME/kg did not affect EW and EM. According to Costa *et al*. (2009), FI, EP, EM, and FCR per EM and per dozen eggs increased significantly with increasing levels of ME from 2650 to 2950 Kcal/kg diets. Egg weight remained same, though. As the energy level of the diet increased, the feed consumption decreased in a linear way. The effect of the metabolizable energy levels on EP, EM and FCR per egg mass and per dozen eggs was quadratic. Additionally, adding fat to the diet may have increased energy and significantly decreased FI, increased EW, and improved FCR (Wu *et al*., 2005).

In respect of protein, our results were consistent with those of Kumari *et al*. (2016), who noticed that a diet high in protein increased body weight. Also, Alagawany *et al*. (2020) found that the hens fed an 18% CP diet had the best final BW and BWC values compared with those fed 16% protein content. Increasing dietary CP up to 18% in association with the best FCR, EM, and EW. The best EP rate was obtained when a diet consisting of 16% CP and 0.72% Met+ Cys was combined. Similarly, Yakout (2010) reported that layers fed high-CP diets achieved the highest body weight gain. In a similar trend Bouyeh and Gevorgian (2011), throughout the EP period, hens provided with a diet high in protein (14%) gave the highest value of body weight compared to those fed a diet low in protein (13%). According to studies by Wu *et al*. (2005), Gunawardana *et al*. (2008), and Zou and Wu (2005), increasing dietary protein intake in the diet led to an increase in EP. In other study, Yakout *et al*. (2004) found that increasing the protein content of layer diets enhanced EP and FCR. In a similar direction, Moustafa *et al*. (2005) found that an increase in the protein level of the layer diet improved the FCR. According to studies by Mareiy *et al*. (2009), laying hens' egg production parameters were improved through better diets that contained high concentrations of nutrients. Feeding high nutrient-density diets may have improved egg production parameters by giving layers an adequate supply of both essential and non-essential amino acids (NRC, 1994). This may have improved nitrogen utilization (Zeweil *et al*., 2011 and Phuoc *et al*., 2019). Bunchasak *et al*. (2005) reported that dietary CP levels (14, 16 and 18% CP) had no significant impact on the FI of laying hens. As well as, Rama Rao and Tirupathi Reddy (2016) illustrated that the EP rate, feed efficiency, EW, and EM decreased in response to a reduction in protein levels (17.5, 16.5, and 15.5% CP) in white leghorn layer diets; however, dietary CP levels had no effect on FI.

Compared to the birds fed 17.5 and 16.5% CP, the ones fed a diet with 15.5% CP laid eggs at a lower rate. On the contrary, Gumpha *et al*. (2019) found that Vanaraja laying hens fed diets containing 13% CP achieved significantly higher body weight gain as compared with 16 and 17.5% CP diets. Furthermore, variations in the CP content of the diet had no effect on the EP, EW, EM per day, or feed efficiency of hen-housed eggs. In the same direction, Zeweil *et al*. (2011) suggested that dietary differences in protein content had no significant impact on FI and EP . Fekadu *et al*. (2022), Z-White chickens fed diets with different protein contents (14.5, 15.5, or 16.5%) and different ME contents (2850, 2750, or 2650 kcal/kg) produced the highest number of eggs and percentage of hen-day EP as a result of feeding on the protein content (15.5%) and ME content (2850 kcal/kg) than those fed the other diets. However, neither the EM nor the hen-day EP rate was significantly affected by different levels of proteins, energy, or their combinations. Hussein *et al*. (2010) demonstrated that the BW and FI of Sinai laying hens were unaffected by dietary energy levels between 2600 and 2800 Kcal ME/kg or protein levels between 14 and 18%. Although the same authors found in another experiment that giving Sinai hens' diets higher energy contents from 2700 to 2800 Kcal ME/kg) led to significantly higher final body weights and body weight gain compared to those given diets with 2600 or 2650 Kcal ME/kg. Furthermore, hens fed a diet containing 2750 kcal ME/kg showed higher DFI than those fed a diet containing 2650 Kcal ME/kg. In another study, EP and EM were higher in Fengda-1 layers fed 14.50% and 15.00% CP than in layers fed 15.50% CP. (Ding *et al*., 2016). As well as Xin *et al*. (2022) conducted a study on Hy-Line brown pullets and reported that hens fed on metabolizable energy at 2,700 and 2,800 kcal/kg and protein levels at 15 and 16.5% CP did not differ among the dietary treatments. It's clear that there isn't any variation in the levels of protein and energy utilized in each of them, which explains why EP traits don't affect protein and energy levels. According to a different study by Kim and Kang (2022) noted that different dietary protein levels (16.5 and 14.5% CP) had no effect on the laying performance of Hy-Line Brown laying hens throughout 30 to 50 weeks of age. Egg weight and feed conversion improved, but FI decreased when diets' energy level was raised from 2700 to 2800 kcal/kg. Tesfaye *et al*. (2019) reported that there were no significant differences in final body weight, EP, EW and FCR when hens fed different protein-energy levels (16-2750, 16.5-2800, 17-2900, and 16% CP-2700 ME kcal/kg diet); however, hens fed the diet with a 16.5% CP and ME at 2800 kcal/kg showed significantly better EM, feed efficiency, and profitability compared to hens fed other diets.

Egg quality:

Table 5 shows the average egg quality measurements for Montazah laying hens as influenced by metabolizable energy, dietary protein levels, and their interaction. Results showed that the measurements of egg quality (egg shape index%, albumen%, yolk%, shell%, shell thickness (mm), Hough unit, yolk index%, specific gravity and ESA) were not significantly ($P > 0.05$) impacted by protein, energy levels or interaction between them. Our findings are in line with those of Alagawany *et al*. (2020), who found that most parameters related to egg quality were not significantly affected by protein levels at 16 or 18%. Also, Shell thickness was not significantly affected by the energy level in the diet. In the same trend, Alderey and Elweshahy (2019) and Alderey (2020) showed that Sinai laying hens fed different levels of protein (14, 16 and18%) and energy (2700 and 2850 ME kcal/kg) displayed insignificant variations in egg quality measurements. According to Hassan *et al*. (2013), hens' egg quality was not significantly impacted by their protein or energy levels. (Hussein *et al*., 2010) found the same findings. Junqueira *et al*. (2006) found that brown egg-laying hens fed diets whose contents ranged from 2850 to 3050 ME (kcal/kg) did not exhibit any changes in Haugh units or eggshell quality. Similar proportions of yolk and albumen were found in the eggs of laying hens fed energy contents ranging from 2750 to 3055 kcal/kg (Gunawardana *et al*., 2008). According to Costa *et al*. (2009), there was no difference in the of yolk%, albumen%, and eggshell%, yolk color and egg specific gravity between diets with an energy level of 2650 to 2950 kcal/kg. Also, Tesfaye *et al*. (2019), who found that there were no significant variations in the egg quality of hens fed diets with different protein-energy levels 16-2750, 16.5-2800, 17-2900, and 16% CP-2700 ME (kcal/kg diet). Contrary Wu *et al*. (2005) found that when the AMEn of the diet increased from 2720 to 2955 kcal/kg, yolk weight increased and Haugh units declined.

In regard to dietary protein levels, our results are consistent with those of Gumpha *et al*. (2019) found that dietary protein levels (14 to 17.5%) had no effect on egg quality measures including albumin%, yolk%, Haugh unit, and egg shell thickness; the only exception was egg shell%, which was higher in the 16% CP diet than in the 13 or 14.5% CP diet. Also, Gumpha *et a*l. (2018) obtained the same previous results with the exception of the albumen and yolk percentages in eggs at 38 weeks of age and the egg shell percentage, which was increased at 16% on a CP diet at 42 weeks of age as compared to 13 and 14.5% on a diet. Furthermore, Zeweil *et al*. (2011) found that protein levels had no impact on most of egg quality characteristics. However, the yolk color index was higher for the layers fed the 14 and 13% CP diets compared to the layers on a regular diet (16% CP) (Torki *et al*., 2016). Fekadu *et al*. (2022) observed that the majority of egg quality parameters were not significantly impacted by the dietary treatments (CP, ME, and their combination) when Z-White chickens were fed diets with varying levels of dietary protein (14.5, 15.5, or 16.5%) and 2850, 2750, or 2650 kcal/kg diet, respectively. A few other studies (Adeyemo *et al*., 2012 and Khajali *et al*., 2007) found that laying hens with higher dietary protein levels produced eggs of higher quality.

Fertility and hatchability:

The data presented in Table 6 showed the effect of dietary energy, dietary protein levels and their interactions on the fertility and hatchability of Silver Montazah laying hens. Although there was a slight improvement in fertility, hatching rates and mean chick weight by increasing energy or protein levels, the results indicated that neither energy levels nor protein levels had any significant effect (P> 0.05) on fertility and hatchability characteristics. Also, the results did not show any significant differences in the interaction between protein and energy levels on the aforementioned traits. Our results agree with those of Alderey and Elweshahy (2019) and Alderey (2020) demonstrated that laying hens fed different levels of energy 2700 and 2850 ME (kcal/kg) and protein (14, 16, and 18%) showed no differences in terms of hatchability and chick weight. In the same trend Fekadu *et al*. (2022) observed that hatchability and fertility were not significantly impacted by the dietary treatments (CP, ME, and their combination) when Z-White hens were fed diets with varied levels of dietary protein (14.5, 15.5, or 16.5%) and a 2850, 2750, or 2650 kcal/kg diet, respectively. They added that as dietary levels of protein and energy increased, correspondingly, hatchability and fertility increased. Similar findings were reported by Tesfaye *et al*. (2019) showed that there were no significant differences in hatchability and fertility among hens fed diets different protein-energy levels (16–17% CP) and 2700–2900 ME (kcal/kg) diet.

Mareiy *et al*. (2009) demonstrated that giving high-nutrient diets to Sinai chickens enhanced hatchability, egg fertility, post-hatch chick weight, yolk index, and Haugh Unit score. On the other hand, Zeweil *et al*. (2011) showed that raising the CP level significantly lowered the percentage of chicks that hatched in Baheij hens. But, Hassan *et al*. (2020) pointed out that increasing the energy diet from 2600 to 2800 kcal/kg significantly improved fertility, chick weight at hatch, and hatchability of all egg sets, but had no effect on the hatchability of viable eggs. This improvement could be due to the big differences in energy levels using.

Table (5): Means of egg quality measurements as affected by metabolizable energy, dietary protein levels and their interaction of Silver Montazah laying hens

Treatments		Egg shape index %	Egg components%			Shell thickness (mm)	Hough Unit	Yolk index %	Specific gravity	Egg surface area
			Albumen	Yolk	Shell					
Metabolizable energy levels,kcal/kg										
2700		76.86±1.18	54.91±0.65	30.97±0.66	14.69±0.68	34.44±038	80.68±0.99	45.00±1.06	1.114±0.00	61.78±1.31
2850		77.84±1.62	54.09±0.46	31.36±0.41	14.02±0.31	34.56±0.24	79.50±0.74	46.55±0.63	1.110±0.00	63.98±1.41
Sig.		NS	NS	NS	NS	NS	NS	NS	NS	NS
Crude protein levels% (CP%)										
14		78.03±2.05	54.55±0.94	30.25±0.75	14.79±0.25	34.50±0.22	79.86±1.13	45.34±0.62	1.114±0.00	65.06±2.19
16		77.52±1.67	54.54±0.29	31.86±0.46	14.25±0.58	34.33±0.42	80.41±1.31	45.64±1.10	1.111±0.00	61.76±1.43
18		76.51±1.60	54.49±0.82	31.39±0.66	14.03±0.97	34.67±0.49	80.00±0.91	46.35±1.53	1.110±0.01	61.82±1.16
Sig.		NS	NS	NS	NS	NS	NS	NS	NS	NS
Interactions										
ME (kcal/kg)	CP%									
	14	77.33±0.70	55.34±1.45	29.55±1.23	15.17±0.28	34.33±0.33	80.27±2.34	45.31±0.72	1.116±0.00	61.71±3.35
2700	16	77.89±2.83	54.64±0.61	32.10±0.95	14.64±1.24	34.33±0.88	81.01±1.64	44.82±2.03	1.113±0.01	62.61±2.93
	18	75.35±2.54	54.74±1.58	31.27±1.09	14.27±1.94	34.67±0.88	80.77±1.84	44.87±2.98	1.111±0.01	61.02±0.35
	14	78.72±4.47	53.58±1.25	30.95±0.91	14.41±0.30	34.67±0.33	79.45±0.84	45.36±1.18	1.112±0.00	68.42±1.19
2850	16	77.14±2.41	54.44±0.16	31.63±0.31	13.86±0.11	34.33±0.33	79.80±2.36	46.46±1.12	1.109±0.00	60.92±0.98
	18	77.67±2.23	54.24±0.89	31.51±0.98	13.80±0.96	34.60±0.67	79.24±0.40	47.84±0.77	1.108±0.01	62.61±2.44
Sig.		NS	NS	NS	NS	NS	NS	NS	NS	NS

NS: not significant*

Table (6): Effect of dietary energy, dietary protein levels and their interactions on fertility and hatchability of Silver Montazah laying hens.

Treatments		Fertility%	hatchability of fertile eggs%	hatchability of total eggs%	Mean chick weight (g)
Metabolizable energy levels,kcal/kg					
2700		86.06±0.35	88.78±0.46	76.40±0.55	33.20±0.48
2850		87.22±0.45	89.30±0.27	77.90±0.58	34.10±0.45
Sig.		NS	NS	NS	NS
Crude protein levels% (CP%)					
14		86.01±0.61	88.69±0.50	76.28±0.84	33.35±0.65
16		86.32±0.41	89.01±0.37	76.83±0.53	33.85±0.53
18		87.60±0.40	89.43±0.52	78.34±0.64	33.75±0.55
Sig.		NS	NS	NS	NS
Interactions					
ME (kcal/kg)	**CP%**				
2700	14	85.21±0.28	88.47±1.04	75.40±1.08	33.10±1.10
	16	85.98±0.77	88.56±0.40	76.15±0.61	33.40±0.69
	18	86.98±0.17	88.29±1.03	77.66±0.87	33.10±0.72
2850	14	86.80±1.08	88.89±0.35	77.17±1.27	33.60±0.76
	16	86.65±0.37	89.45±0.58	77.51±0.75	34.30±0.82
	18	88.21±0.61	89.56±0.53	79.01±0.92	34.40±0.82
Sig.		NS	NS	NS	NS

NS: not significantly.*

Blood parameters:

The results, which are displayed in Table 7, demonstrated that dietary energy or protein and their interaction levels had no significant effects on the majority of blood parameters, including total protein, albumin, globulin, and glucose. Feeding birds on a high-energy diet exhibited a significantly ($P< 0.01$) higher plasma cholesterol level compared to feeding them on a low-energy diet. On the other hand, AST significantly decreased when birds were fed a high-energy diet compared to those fed a low-energy diet. Hens provided with high dietary protein (18%) displayed a significant ($P< 0.01$) increase in ALT compared to those fed 14 or 16%.

In regard to the effect of the interaction between energy and protein levels, results showed that there were insignificant differences on total protein, albumin and globulin, while the differences between treatments were significant in terms of AST, ALT and cholesterol. Whereas, birds which provided with diet-low energy (2750 ME,kcal/Kg) with any protein level recorded the higher values of AST than those fed other diets, in addition, birds fed a high-energy diet with a protein level of 14% have the lower value of AST compared to other treatments. The highest values of ALT were observed for birds receiving low energy content with an 18% protein level followed by that fed high-energy-protein diet. On the other side, the cholesterol level increased gradually with increasing protein and energy levels in the diets. Our results are in line with our previous research (Alderey and El-Weshahy 2019), who found that energy levels had no effect on the characteristics mentioned, with the exception of cholesterol, which increased as diet energy increased, while, AST decreased. Also, Nofal *et al*. (2018) found that feeding energy-diets (2800 kcal/kg diet) to laying diets increased blood plasma cholesterol when compared to low-energy diets (2600 kcal/kg diet), but glucose and albumin levels were unaffected. A similar study (Xin *et al*., 2022) found no negative impact on serum biochemical levels from lowered CP diets. According to Hassan *et al*. (2013), there was not a significant impact on the blood components in Brown nick laying chickens fed diets containing (2750, 2775, and 2800 kcal of ME/kg) and CP (16 and 17%). Hussein *et al*. (2010) achieved the same results. In addition, Heo *et al*. (2023) found that lowering the CP levels of poultry diet up to 130 g/kg had no effect on total protein, albumin, or cholesterol levels in the blood. Kim and Kang (2022) found that blood biochemistry values (total cholesterol, triglyceride, total protein, AST, and ALT) did not change by energy levels (2800 or 2700 kcal/kg), CP (14.5 and 16.5%), or their interaction in the diet. Also, differing CP levels in diets did not affect any of the blood characteristics.

Hens on a high CP diet (20%) exhibited a higher blood total protein concentration and AST than birds fed a low CP diet (16%). However, a decrease in CP in the diet led to an increase in ALT (Alagawany *et al*., 2011). On the other hand Gumpha *et al*. (2019) reported that serum biochemical parameters like concentration of total protein, globulin, calcium, cholesterol, creatinine and alkaline phosphatase were significantly influenced by feeding laying hens at dietary protein levels ranging from 14 to 17.5%.

Table (7): Effect of dietary energy, protein levels and their interactions on blood parameters of Silver Montazah 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
Metabolizable energy levels,kcal/kg								
2700		4.31±0.05	2.48±0.05	1.83±0.04	21.56±0.75^{a}	25.89±1.06	114.56±0.77^{b}	248.44±1.00
2850		4.42±0.06	2.47±0.06	1.95±0.08	17.22±0.70^{b}	26.67±0.62	124.67±0.93^{a}	250.44±0.67
Sig.		NS	NS	NS	**	NS	**	NS
Crude protein levels% (CP%)								
14		4.27±0.06	2.43±0.06	1.84±0.07	17.83±1.40	24.83±0.87^{b}	118.50±2.19	249.33±0.99
16		4.34±0.02	2.47±0.07	1.87±0.07	21.00±1.29	24.83±0.48^{b}	119.43±2.50	248.33±1.12
18		4.48±0.08	2.52±0.07	1.97±0.10	19.33±0.84	29.17±0.48^{a}	120.50±2.72	250.67±1.15
Sig.		NS	NS	NS	NS	**	NS	NS
Interactions								
ME (kcal/kg)	**CP%**							
2700	14	4.23±0.07^{bc}	2.43±0.12	1.80±0.06	20.67±0.88^{b}	23.33±0.88^{e}	114.00±1.53^{c}	248.67±1.76
	16	4.33±0.03^{bc}	2.53±0.09	1.80±0.06	23.67±0.88^{a}	24.67±0.88^{d}	114.67±1.76^{c}	246.33±0.88
	18	4.37±0.12^{c}	2.47±0.03	1.90±0.10	20.33±1.33^{b}	29.67±0.88^{a}	115.00±1.16^{c}	250.33±2.03
2850	14	4.31±0.11^{ab}	2.43±0.07	1.88±0.13	15.00±1.00^{c}	26.33±0.88^{c}	123.00±1.16^{bc}	250.00±1.16
	16	4.34±0.03^{ab}	2.40±0.12	1.94±0.11	18.33±0.67^{b}	25.00±0.58^{de}	125.00±1.16^{ab}	250.33±1.20
	18	4.60±0.06^{a}	2.57±0.15	2.03±0.18	18.33±0.88^{b}	28.67±0.33^{b}	126.00±2.31^{a}	251.00±1.53
Sig.		NS	NS	NS	**	**	**	NS

**Aspartate transaminase (AST) **Alanine amino transferees (ALT) NS = not significant*
*$^{a-e}$ Means in a column with different superscripts differ significantly (P≤ 0.05) , **:P≤ 0.01.*

Economic efficiency:

Table 8 presents a summary of the economic efficiency results. It was evident that the increases in energy level from 2700 kcal/kg to 2850 kcal/kg caused body weight to increase, which in turn had a positive effect on increasing the revenue of both change in body weight and fertile eggs/hens in response to feeding hens on a high-energy diet. This ultimately resulted in an increase in net revenue and a great increase in economic efficiency. Concerning protein levels, results revealed that by increasing the protein level up to 18%, there was a gradual increase in both the price of feed costs, revenue from CBW, revenue from fertile eggs/hen, total revenue and net revenue, but relative economic efficiency was reduced when increasing the protein level from 16 to 18%.

This was due to an increase in feed costs that increased by 5.79% while net revenue only increased by 3.87%. In regard to the effect of the interaction between dietary energy and protein levels on Silver Montazah laying hens' economic efficiency, It was shown that all birds fed diets with high energy content (2850 kcal/kg) with any dietary protein level had higher economic efficiency values than those fed diets with low energy content. Nonetheless, hens fed a high-energy diet with 16% protein content achieved the best economic efficiency, followed by hens fed an 18% dietary protein diet with the same energy level. This is due to a reduction in feed costs and an increase in net revenue compared to other diets. Conversely, the lowest economic efficiency was found in birds fed low dietary energy level with 18% protein in their diet. It could be concluded that the best relative E.E. (%) was achieved when fed hens a diet containing 16% protein and a 2850 kcal/kg diet.

Table (8): Effect of dietary energy and protein levels and their interactions on the economic efficiency (EE) of Silver Montazah 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		11.82	14.54	171.86	135.55	517.01	652.56	480.70	279.74
2850		11.25	15.29	171.98	187.75	525.84	713.59	541.61	314.81
Crude protein levels% (CP%)									
14		11.66	14.15	164.85	140.53	506.52	647.05	482.20	292.45
16		11.51	14.80	170.23	159.46	526.00	685.46	515.24	302.66
18		11.44	15.81	180.70	184.95	531.76	716.71	536.01	296.72
Interactions									
ME (kcal/kg)	**CP %**								
2700	14	11.90	13.79	164.10	117.78	501.52	619.30	455.20	277.39
	16	11.81	14.40	170.06	135.11	520.00	655.11	485.05	285.21
	18	11.75	15.44	181.42	153.75	529.52	683.27	501.85	276.62
2850	14	11.42	14.50	165.59	163.28	511.52	674.80	509.21	307.51
	16	11.21	15.20	170.39	183.82	532.00	715.82	545.43	320.10
	18	11.13	16.17	179.97	216.15	534.00	750.15	570.18	316.82

CONCLUSION

It could be concluded that the best feed efficiency and productive performance were achieved for hens of received diet contained 16% protein with 2850 kcal/kg diet.

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الأداء الانتاجى لدجاج المنتزة الفضى المغذى على علائق تحتوى على مستويات مختلفة من البروتين والطاقة

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يؤدى محتوى الطاقة والبروتين في النظام الغذائي دورًا مهمًا في ضبط استهلاك الطائر لتلبية احتياجاته للنمو والبدء في إنتاج البيض. كان الغرض من هذه الدراسة هو النظر في كيفية تأثير مستويات الطاقة والبروتين على أداء وضع البيض وجودة البيض والخصوبة ومعدل الفقس وبعض مقاييس الدم. تم تقسيم 144 دجاجة منتزه فضي بعمر 24 أسبوعًا بشكل عشوائي إلى ستة معاملات في تصميم عاملي 2 × 3 باستخدام مستويين من الطاقة الممثلة (2700 و 2850 كيلو كالورى ME / كجم) وثلاثة مستويات من البروتين: منخفض (14٪) ومتوسط (16%) وعالى (18%). تم تسكين الطيور في أقفاص فردية، 24 دجاجة لكل معاملة. ويمكن تلخيص النتائج على النحو التالي:

- الطيور التي تم تغذيتها على المحتوى العالى من الطاقة أظهرت زيادة معنوية في وزن الجسم النهائي ، التغير في وزن الجسم، التحويل الغذائي، مقاييس إنتاج البيض ومستوى الكوليسترول مقارنة بالعلائق المنخفضة الطاقة. ومع ذلك، فإن الدجاج الذي تم تغذيته على علائق منخفضة الطاقة أدى الى زيادة معنوية في المأكول اليومى من العليقة، البروتين المأكول اليومي، الكفاءة النسبية للبروتين ، وكفاءة الطاقة الممثلة.

- أظهرت الطيور التي تم تغذيتها على علائق تحتوي على 18% بروتين أظهرت زيادة معنوية في وزن الجسم النهائى، والتغير فى وزن الجسم، وكفاءة تحويل الغذاء، ومقاييس انتاج البيض والمأكول اليومى من البروتين، ونسبة كفاءة البروتين ، وكفاءة الطاقة الممثلة وأنزيم آلانين امينو ترانسفيريز مقارنة بتلك التي تم تغذيتها على علائق تحتوي على 14% بروتين.

- أظهرت الطيور التي تم تغذيتها بـ 16 أو 18% من البروتين مع مستوى الطاقة العالى تحسنا في وزن الجسم النهائى، والتغير فى وزن الجسم، وكفاءة تحويل الغذاء، ومقاييس انتاج البيض. اضافة الى ذلك ، زادت مستويات الكوليسترول في الدم بشكل ملحوظ مقارنة بالمعاملات الأخرى. علاوة على ذلك ، فإن الدجاج الذي تغذى على عليقة 16% بروتين مع مستوى الطاقة المنخفض سجل أعلى القيم لانزيم للأسبرتات ترانسفيريز ، إلا أن نفس مستوى الطاقة مع 18% بروتين أدى إلى زيادة معنوية في آلانين امينو ترانسفيريز مقارنة بالمعاملات الأخرى.

ومن وجهة النظر الاقتصادية يتضح أن النظام الغذائي التي تحتوي على 16% بروتين و2850 كيلو كالورى/كجم هو النظام الأمثل لدجاج المنتزه الفضي البياض لتحقيق أقصى أداء إنتاجي خلال فترة الدراسة التي تتراوح من 24 إلى 39 أسبوعًا.