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Response of High Dietary Energy Profile Meal from Processed Maize Products on Performance Parameters and Egg Quality of Shaver Brown Laying Birds

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Abstract

An experiment was carried out with One hundred and twenty 23-week-old shaver brown laying hens to investigate production responses, egg quality and energy utilization of laying hens fed different dietary energy levels of extras from processed maize at the beginning of lay. Birds were housed and divided infive groups of 25 birds per treatment according to dietary substitution levels at 2700 kcal/kg; 2775 kcal/kg;2850 kcal/kg; 2925 kcal/kg; and 3000 kcal/kg respectively with five replicates of 5 birds each. Birds were fed the experimental diets based on corn and soybean meal for 7 weeks. Increasing levels had a negative effect on egg production and egg mass (p≤0.05). Substitution levels did not influence body weight, egg weight, or livability (p>0.05). Increasing dietary levels increased (p≤0.05) feed intake and feed conversion ratio. There were no differences in albumen height, yolk total solids content, or egg component percentages (p>0.05). Egg specific weight improved with increasing dietary levels (p≤0.05). Therefore, the energy level of 2700 kcal/kg of feed may be fed to young laying hens.

Keywords: *Shaver Brown Laying Hens, Production Responses, Egg Quality and Energy.*

Introduction

There is a wide variation in the recommendations of energy levels for commercial laying hens among strain management guides and between these guides and tables developed by research institutions, such as the NRC (1994) and Rostagno *et al.*, (2005). Feeding inadequate energy levels may result in low egg production, body weight and worse egg quality (Uzoma and Olowo, 2016). The efficiency of energy utilization may also be impaired (Ahaotu *et al.*, 2016 a), Araujo and Peixoto, 2005). Wu *et al.* (2005) observed that feeding increasing high energy levels to 21-week-old shaver brown hens reduced feed intake in 1% for each 39 kcal/kg increase in dietary levels, and affected egg and yolk weights, but not egg production, egg mass, body weight, or livability. Those authors also found effects of high dietary levels on internal and external egg quality, in agreement with their previous findings (Wu *et al.*, 2007). However, Jalal *et al.* (2006) fed young Hy-lineW-36 laying hens (21 weeks old) diets with high energy levels of 2800,2850, and 2900 kcal/kg and did not observe any differences in feed intake. Jalal *et al.* (2007) used 22- to 50-week-old white and brown layers (Hy-Line W-36, Hy-Line Brown, Babcock B300, and Shaver White) totwo dietary levels (2810 and 2900 kcal/kg feed) and the dietary supplementation of a commercial enzyme complex to the lowest energy feed, but did not find any differences in body weight, weight gain, feed intake, egg weight, egg production, or egg mass. The only difference found was in intake, which was the highest for the birds fed the highest energy level. In addition, egg quality parameters, such as specific gravity, egg shell thickness, yolk and albumen percentages, and yolk solids content, were also not influenced by higher energy level, as expected. The study evaluated the production performance, egg quality and energy utilization of young commercial laying hens fed diets containing different levels of high concentrations of extracts from processed maize.

Materials And Methods

The experiment was carried out at the Teaching and Research Farm of Imo State Polytechnic

Umuagwo. This experiment lasted for a period of five weeks. The mean annual rainfall recorded was 1398mm while mean monthly temperature of 22.71ºC and average monthly relative humidity of 75.54% were also recorded (IMLS, 2009).

Bird Management

In the trial, 120layers were housed in 30 x 45cm battery cages with four birds per cagein open-sided layer houses. Each experimental unit consisted of 24 birds, housed in a total of 5 cages, with five cages placed in the upper tier and five in the lower tier for the same replicate. There were four replicates pretreatment, totaling 6 birds per replicate. Cages were equipped with manual feeders and nipple drinkers. The average initial weight was 1487g, and was not different among replicates (p=0.65 and SEM=0.03).

Birds were submitted to lighting program of 16 hours of light/day(natural and artificial light). Water and feed were offered *ad libitum*, and eggs were collected daily.

Dietary Treatments

Feed composition and their calculated nutritional concentration are shown in Table 1.Treatments consisted of dietary levels of2700, 2775, 2850, 2925 and 3000 kcal/kg feed. All levels of all other nutrients, such as crude protein, amino acids, minerals and vitamins, were the same for all treatments, independently of the dietary level.

Table1. *Feed Composition and Calculated Nutritional Levels*

Ingredients	Treatments(kcal/kg feed)				
	2700	2775	2850	2925	3000
Maize grain	54.00	34.00	14.00	4.00	0.00
Extracts from					
Processed Maize	0.00	20.00	40.00	50.00	54.00
Soybean meal	25.00	25.00	25.00	25.00	25.00
Palm Kernel Cake	10.00	10.00	10.00	10.00	10.00
Wheat Offals	5.00	5.00	5.00	5.00	5.00
Bone meal	4.90	4.90	4.90	4.90	4.90
Salt	0.28	0.28	0.28	0.28	0.28
DL-Methionine	0.12	0.12	0.12	0.12	0.12
Lysine	0.25	0.25	0.25	0.25	0.25
Choline chloride	0.04	0.04	0.04	0.04	0.04
Layers Premix	0.41	0.04	0.04	0.04	0.04
TOTAL (%)	100.00	100.00	100.00	100.00	100.00
Calculated nutritional levels					
Linoleic acid (%)	1.41	1.42	1.94	2.64	3..37
Calcium (%)	3.60	3.60	3.60	3.60	3.60
Choline (mg/kg)	1179	1175	1182	1172	1174
Available phosphorus (%)	0.41	0.40	0.40	0.40	0.40
Total phosphorus(%)	0.63	0.60	0.59	0.59	0.58
Digestiblelysine(%)	0.76``	0.77	0.78	0.78	0.78
Dig Methionine + Cystine (%)	0.61	0.61	0.61	0.61	0.61
Digestible Methionine (%)	0.36	0.36	0.36	0.36	0.36
Crude protein (CP) (%)	17.3	17.3	17.3	17.3	17.3
Sodium (%)	0.18	0.18	0.18	0.18	0.18

1 Supplied per kilogram of diet: Vitamin supplement: Vit. A 10,000 IU, Vit. D_3 2,500 IU, Vit E 15 IU, Vit. B_1 2 mg, Vit.B_2 4mg, Vit.B_6 4 mg, Vit.B_{12} 15 mg, Vit. C 50 mg, niacin 30 mg, folic acid 0.5 mg, pantothenic acid 16 mg, biotin 0.06 mg,and BHT 125 mg. Mineral supplement: manganese 200 mg from manganese oxide, zinc 125 mg from zinc oxide, iron 50mg from ferrous sulfate, copper 15 mg from copper sulfate, iodine 1.880 mg ethylene diamine dihydroidide, selenium 0.4mg from sodium selenite. Average metabolizable energy (AMEn) levels were

determined by the addition of soybean oil and wheat middling, fiber and fatty acid levels were different among diets, and, according to Oliveira (2009), the inclusion of linoleic acid do not affect layer performance unless it greater than 1%.Performance evaluation Egg production was daily recorded, and lay percentage calculated based on weekly results. Eggs were weekly weighed to calculate average egg weight. Daily mortality was recorded, and livability was calculated as a percentage of mortality. Egg mass was calculated by multiplying average egg weight by egg production percentage. Feed intake was calculated by subtracting feed residues weight from total feed weight offered during the week.

Daily energy intake was calculated based on the calculated dietary AMEn level content and daily feed intake per bird, and expressed in kcal/bird/day. Similarly ,the intake of calcium (Ca), available phosphorus (AvP),crude protein (CP), and digestible sulfur amino acids(digestible methionine + Cystine; dSAA) was calculated based on the calculated dietary levels of these nutrients and on feed intake.Feed conversion ratio was calculated as grams of feed intake/gram of egg produced and by kilograms of feed intake/dozen eggs produced. Energy conversion ratio was determined using feed conversion ratio and dietary AMEn level. Egg quality parameters The egg quality parameters yolk, albumen, and egg shell percentages; total yolk solids; egg specific gravity; Haugh Units (HU); and yolk color were analyzed in five eggs per replicate that were randomly collected every three weeks. Egg specific weight was determined in 30 randomly-chosen eggs per replicate that were laid during in the last three days of every three-week period.

After individually weighed in a digital analytical scale (0.01g precision), eggs were broken, and albumen, yolk, and eggshell were separated. Yolks were individually weighed. Eggshells were washed to remove albumen residues, dried at room temperature for 48h, and then individually weighed. Albumen weight was determined as the difference between intact egg weight minus the sum of yolk and egg shell weights. Total yolk solids were determined in five replicates of pools of five yolks each. Yolk was weighed, placed in individual containers, and dried in an incubator at 65+/-5 ^{o}C for 72 hours, and weighed again. Yolk solids content was calculated as the difference between initial and dry weights (Brasil, 1999).For HU analysis, eggs from five replicates of six eggs (n=30) were collected per treatment. Eggs were individually weighed and broken to measure albumen weight using a HU-measuring device (Ames, modelS-8400, Massachusetts, USA) (Haugh, 1937).Egg specific weight was determined in 30 eggs per replicate produced during the last three days of the week, every three weeks, by immersing eggs in graded saline solutions. Egg color was measured using a colorimetric fan (DSM YOLK COLOR FAN, 2005 –HMB 51548).

Statistical Analysis

A completely randomized experimental design, consisting of five treatments with six replicates of 40birds each, was applied. Data were subjected to analysis of regression using linear and quadratic polynomials (Sampaio, 2007) using SAEG (2005) statistical package. Dietary AMEn level was the independent variable that described the effects on the studied parameters. All coefficients of the obtained equations were significantly different from zero (p>0.05). Livability data were submitted to square root transformation to obtain normal distribution, but are presented as actual values. As yolk color was subjectively evaluated, the obtained data were submitted to the non-parametric test of Kruskal Wallis, according to the recommendations of Sampaio (2007)

Results and Discussion

Effects of High Dietary Energy on the Performance Parameters

The effects of dietary high level on the performance parameters are shown in Table 2. Dietary higher levels influenced feed intake (p=0.0013). The regression analysis indicated that the equation that explains its effect is: y = -0.033564X + 188.35559 (r2=0.96).Most studies in literature also reported reducing feed intake as dietary energy increases (D'Alfonso *et al.*,1996; Grobas *et al.* 1999a; Harms *et al.*, 2000; Wu *etal.*, 2005; 2007). According to Wu *et al.* (2005), feed intake is reduced in 1% for every 39 kcal/kg increase, as found in the present study. These results indicate that poultry regulate their feed intake as a function of dietary high level. The energy change required to regulate feed intake were similar to the range used in the present study (75 kcal/kg feed), as no statistical differences were detected when all treatments were compared. On the other hand, Valkonen *et al.* (2008)observed increasing feed intake with increasing dietary energy levels; however, the authors used very low high levels (2390 and 2629 kcal/kg feed), but as feeds contained equal nutrient concentrations, except for energy, feed intake may have been limited by the excessive supply of some other nutrient.

There was no effect of high level on high intake (p=0.3978; Table 2). These results were also obtained by Grobas *et al.* (1999a) and Jalal *et al.* (2006). The results of the present study are consistent with the findings of Leeson and Summers (2005), who reported a high intake of 260 kcal/day/bird in 18- to32-week-old layers. According to Bertechini (1998), commercial laying hens tend to regulate their feed intake as a function of their energy requirement, and therefore, birds with similar production level, bodyweight, and genetic strain, and submitted to similar management and environmental conditions, tend to regulate their energy intake, independently of feeding regime. Although this is observed in the field and it is supported by literature, some authors obtained different results.

For instance, D'Alfonso *et al.* (1996)found that increasing dietary energy levels reduced energy intake, whereas Harms *et al.* (2000), Araujoand Peixoto (2005) and Jalal *et al.* (2007) reported higher energy intake as dietary high levels increased. Egg production linearly decreased with increasing high levels (p=0.0118), as shown by the equationy = -0.0183376X + 141.805 (r2=0.85). These resultsare different from those obtained by other authors(D'Alfonso *et al.*,1996; Keshavarz, 1998; Grobas *et al.*,1999a,b; Harms *et al.*, 2000; Costa *et al.*, 2004; Wu *et al.*, 2005, 2007; and Jalal *et al.*, 2006 and 2007),who did not observe any egg production differences in young laying hens fed different AME n levels. On the other hand, Araujo and Peixoto (2005) obtained the equation: y = -251.419079 + 0.2546842X – 0.00004868X2, demonstrating that low high levels increased egg production of laying hens. This is consistent with the findings of Valkonen *et al.* (2008),who used much lower high levels than those applied in the present study and observed an increase in egg production. Araujo and Peixoto (2005) used similar high levels as the present study, and also observed a trend of egg production reduction as high level increased.

This may be explained by the fact that the diets did not present the same energy levels and that birds reduced their feed intake as high level increased. Therefore, egg production was limited by nutrients, such as aminoacids, rather than energy concentration. There was no effect of high on egg weight(p=0.1272; Table 2). This result is consistent with the findings of several authors (Keshavarz, 1998;Grobas *et al.* 1999a,b; Costa *et al.*, 2004; Araujo and Peixoto, 2005; Jalal *et al.*, 2006, 2007; Silva *et al.*,2007; Valkonen *et al.*, 2008), who did not detect any differences in the egg weight of young laying hensfed different high levels.

Table2. *Effect of dietary energy levels on egg production, egg weight, egg mass, feed intake, body weight,and livability of young laying hens(23 to 40 weeks of age).***

Treatment (kcal/kg)	2700	2775	2850	2925	3000	Lin	Quad	r2	SEM
Egg production (%)	92.86	89.90	89.35	89.36	86.25	*	ns	0.85	0.27
Egg weight (g)	59.64	60.12	59.11	59.52	59.09	ns	ns	-	0.11
Eggmass(gegg/bird/day)	55.38	54.05	52.81	53.19	50.96	*	ns	0.88	0.19
Feed intake (g/bird/day)	97.60	95.17	92.46	91.38	86.89	*	ns	0.96	0.28
FCR (g feed/g egg)	1.76	1.76	1.75	1.71	1.70	*	ns	0.90	0.01
FCR (g feed/dz egg)	1.26	1.27	1.24	1.23	1.21	*	ns	0.87	0.01
Higherconv.(kcal/g egg)	4.75	4.88	4.98	5.02	5.11	*	ns	0.96	0.01
Livability (%)	92.91	94.86	94.16	92.91	94.58	ns	ns	-	0.76

** – $p \leq 0.05$*

ns – not significant: $p > 0.05$

*** – six replicates per treatment with 40 birds each.*

On the other hand, Harms *et al.* (2000) and Wu *et al.* (2005; 2007) obtained apositive linear effect of increasing high concentration on egg weight According to Leeson and Summers(2005), dietary protein level has a stronger influence on egg weight than energy level itself. As energy levels increased, feed intake was reduced, but amino acid intake was sufficient to maintain similar egg weight in all treatments. Egg mass was influenced (p=0.0084) by high level(Table 2).

The regression analysis yielded the equationy = -0.012928X + 90.124850 ($r2=0.88$). This result is different from those obtained by other authors (D'Alfonso *et al.*, 1996; Keshavarz, 1998; Grobas *etal.* 1999a,b; Araujo and Peixoto, 2005; Wu *et al.*, 2005;Jalal *et al.*, 2007; Valkonen *et al.*, 2008), who did not find any influence of dietary high level on egg mass. However, Wu *et al.* (2007) showed that eggmass increases as a function of dietary higher levels.

In the present experiment, as egg production decreased with increasing high level and egg weight was not different among treatments, it was expected that egg mass would also decrease as dietary higher levels increased. In the beginning of the experiment, bird weight was equalized to an average of 1360 g, and a range of 10% higher or lower body weight was accepted. Body weight at the end of the experiment was not influenced by dietary high level (p=0.3571, Table2). The results of the present study are consistent with other literature reports (D´Alfonso *et al.*, 1996; Keshavarz, 1998; Grobas *et al.*, 1999a and b; Araujo and Peixoto, 2005; Jalal *et al.*, 2006, 2007; Valkonen *et at.*, 2008). According to Leeson and Summers (2005), layer live weight hardly changes as a function of diet.

In general, weight differences are due to lack of flock uniformity, which is more related to management aspects than to nutritional strategies, because birds of different weights present different nutritional requirements. Bird livability was also not influenced (p=0.1245) by high concentration (Table 2).Although the experimental feeds contained different energy levels, their nutritional levels were similar, and therefore, macronutrient intake was the same as feed intake. Means and coefficients of regression are shown in Table 3. The regression equation y = -0.005827X +32.69835 represents the effect of dietary high level on crude protein intake (p=0.0013); the equation y =-0.000205X + 1.149027 represents the effect of dietary high level on digestible sulfur amino acid intake(p=0.0013); the equation y = -0.01208X + 6.780673represents the effect of dietary high level on calciumin take (p=0.0013); and the equation y = -0.000134X +0.75333 represents the effect of dietary high level on available phosphorus intake (p=0.0013). The r2 value obtained for these equations is the same: 0.96.According to Leeson and Summers (2005) and Rostagno *et al.* (2005), feeding programs of laying hens are commonly established as a function of feed intake. However, feed intake is influenced by several factors, such as egg production, bird age, and management and environmental aspects. In addition, layinghens adjust their feed intake by their energy intake (Bertechini, 1998), but there are no evidences that this applies to other nutrients, such as protein. Although energy intake is not a perfect mechanism regulating feed intake in laying birds, feed energy density is a significant limiting factor of feed intake. Because crude protein, calcium and available phosphorus concentration were constant in the experimental feeds and feed intake decreased as a function of high level increase, there was an important reduction in the intake of these nutrients. This may partially explain the better performance of the birds fed lower high concentration, possibly because those nutrients were not adequately supplied when higher energy level diets were fed. Feed conversion ratio was influenced by dietary high level, as shown in Table 3. The analysis of regression yielded the equation y = -0.000208X +2.333480 ($r2=0.90$) that represents the effect of high concentration on the feed conversion ratio of young laying hens (p=0.0068).

Feed conversion ratio perdozen eggs was also affected, as shown by equation y= -0.000196X + 1.801573 ($r2=0.87$), indicating a linear improvement of feed conversion ratio per dozen eggs as high concentration increased (p=0.0095).Feed conversion ratio, calculated both per kg eggs and per dozen eggs, presented negative linear behavior that is, feed conversion ratio decreased, and therefore improved as dietary high levels increased. These results are different from those reported by some authors, who did not find any influence of high level on feed conversion ratio (Keshavarz, 1998;Grobas*et al.*, 1999a; Costa *et al.*, 2004), but agree with the findings of others (Grobas *et al.*, 1999b; Wu *et al.*, 2005, 2007; Volknen *et al.*, 2008). The inclusion of soybean oil in energy-rich diets has a positive effect on feed conversion ratio due to its extra-caloric effect and because it reduces feed passage rate (Bertechini,1998). Grobas *et al.* (1999b) mentioned that, in general, the effects of dietary energy level on feed conversion ratio of layers are masked by the use of oils and fats in higher energy diets.

The regression equation indicates that increasing high level negatively affected the efficiency of energy conversion ratio (p=0.0012, Table 3). The equation that represents this effect is: y = 0.001141X+ 1.703423 ($r2=0.96$). There are few data available in literature on the energy conversion ratio in layers. Jalal *et al.* (2006) and Valkonen *et al.* (2008), working with young layers, did not find any statistical differences in energy conversion ratio.

On the other hand, the findings of Araujo and Peixoto (2005) were consistent with the results of the present study. They determined a negative linear regression equation for the energy conversion ratio of brown laying hens during the initial phase of lay. According to Peguri and Coon (1991) ,the efficiency of dietary energy utilization both for weight gain and egg production tends to decrease as dietary energy density increases. When increasing dietary energy level were fed, egg production was reduced, but egg weight and higher intake remained constant, probably because the birds fed the higher energy diets consumed excessive energy but the concentration of the other nutrients was low, resulting in worse energy efficiency. Therefore, it is possible to conclude that there is an inverse relationship between feed conversion ratio, which improves with increasing AMEn level probably due to the dietary addition of oils and/or fats, and energy efficiency, which tends to worsen as dietary energy levels increase.

Table3. *Effect of dietary energy levels on macronutrient intake (CP, dSAA, Ca and AvP), feed conversion ratio (g feed/g eggand g feed/dozen eggs) and Feed conversion ratio (kcal/g eggs) de young laying hens (23 to 40 weeks)**.*

Treatment (kcal/kg)	2700	2775	2850	2925	3000	Lin	Quad	r2	EM
CP intake (g/bird/day)	16.94	16.52	15.05	15.86	15.08	*	ns	0.96	0.05
dSAA intake (g/bird/day)	0.59	0.58	0.56	0.56	0.53	*	ns	0.96	0.01
Ca intake (g/bird/day)	3.51	3.43	3.33	3.29	3.12*	ns	0.96	0.01	
AvP intake (g/bird/day)	0.39	0.38	0.37	0.36	0.35*	ns	0.96	0.01	
Feed intake (kcal/bird/day)	263.48	264.09	263.51	267.30	260.67	ns	ns	-	0.82

** – $p \leq 0.05$*

ns – not significant: p> 0.05

*** – six replicates per treatment with 40 birds each.*

There was a linear reduction of yolk percentage as AMEn concentration increased (p=0.024), as shown by the equation y = -0.002012X + 29.84753 (Table 4).Although the p value of this equation was significant, its coefficient of determination was low (r2=0.5565), rendering the equation estimates unreliable (Sampaio,2007), possibly because the model does not fit the observed dispersion of the data.

Table4. *Effects of energy levels on egg component percentages, egg specific weight, percentage of yolk solids, HaughUnits, and yolk color of young laying hens (23 to 40 weeks)***.*

Treatment (kcal/kg)	2700	2775	2850	2925	3000	Lin	Quad	r2	SEM
Yolk (%)	24.60	23.90	24.27	24.01	23.79	*	ns	-	0.90
Albumen (%)	66.23	66.59	66.26	66.66	66.50	ns	ns	-	0.08
Eggshell (%)	10.20	10.18	10.24	10.24	10.37	ns	ns	-	0.03
Specific gravity (g/cm3)	1.0903	1.0900	1.0904	1.0906	1.0912	*	ns	0.70	0.01
Yolk solids (%)	51.60	51.66	51.75	51.16	52.19	ns	ns	-	0.12
Haugh Units	97.21	98.27	96.97	96.49	97.24	ns	ns	-	0.23
Yolk color **	6.24	6.28	6.25	6.32	6.24	-	-	-	-

** – $p \leq 0.05$*

*** – Submitted to the Kruskal-Wallis test at p > 0.05*

ns – not significant: p > 0.05

**** – six replicates per treatment with average of 120 eggs evaluated for specific gravity and 24 for the other parameters.*

There was no influence of high concentration on albumen percentage (p=0.2051) or on egg shell percentage (p=0, 127), as shown in Table 4. Jalal *e tal.* (2007) and Wu *et al.* (2007) obtained comparable results with increasing high levels, while Valkonen *et al.* (2008) observed that laying hens fed low energy diets produced eggs with high yolk percentage and low albumen percentage. According to Bertechini (1998),the ratios among egg components are mainly determined by management factors and bird age, and suffer little influence of nutrition. Egg specific weight linearly increased with increasing dietary higher levels (p=0.003, Table 4). The equation obtained was y = 0.00003X + 1.1081783 (r2=0.70). Jalal *et al.* (2007) and

Valkonen *et al.* (2008) did not find any influence of dietary high level on the specific weight of layer eggs. Despite the statistical difference, the obtained figures were very close. Very low coefficients of variation may indicate significant statistical differences when in fact they do not exist (Sampaio,2007). Therefore, the studied higher levels may not account for any negative effects on the specific weight of young layer eggs. Nevertheless, Wu *et al.* (2005,2007) obtained opposite results: increasing higher levels reduced egg specific weight, as determined by high egg weight and worse eggshell quality, probably because of lower calcium consumption. The percentage of yolk solids was not influence dby the evaluated dietary high levels (p=0.236, Table4). Consistent results were obtained by Oliveira (2009), who fed young layer with different lipid sources, as well as by Jalal *et al.* (2007) and Wu *et al.* (2007), when evaluating different dietary energy levels for young laying hens. There was no effect of higher levels HU values of the eggs of young laying hens (p=0.363, Table 4). Silva *et al.* (2007) found a positive quadratic effect in HU as higher intake increased, whereas Wu *et al.* (2005,2007) reported a reduction in HU values as high concentration increased. There was no influence of dietary feed concentration on yolk color (p>0.05, Table 4). This result is consistent with the findings of Wu *et al.*(2007), who did not detect any effects of high levels on yolk color, whereas Silva *et al.* (2007) found higher yolk color values in the eggs of laying hens fed diets with higher oil content.

CONCLUSION

Egg production linearly decreased as energy levels increased from 2700 to 3000 kcal/kg of feed, where as energy intake and egg weight were not affected by dietary energy levels. Because this effect is linear, further studies should be performed using dietary lower energy levels. Energy levels of 2700 kcal/kg of feed may be fed to young laying hens.

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