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Metabolizable energy and oil intake in brown commercial layers

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ABSTRACT - With the objective to establish the best metabolizable energy (ME) intake for layers, and the best dietary vegetable oil addition level to optimize egg production, an experiment was carried out with 432 30-week-old Hisex Brown layers. Birds were distributed into nine treatments with six replicates of eight birds each according to a 3 × 3 factorial arrangement, consisting of three daily metabolizable energy intake (280, 300 or 320 kcal/bird/day) and three oil levels (0.00; 0.75 and 1.50 g/bird/day). Daily feed intake was limited to 115, 110 and 105 g/bird in order to obtain the desired energy and oil intake in each treatment. The following parameters were evaluated: initial weight, final weight, body weight change, egg production, egg mass, feed conversion ratio per dozen eggs and per egg mass and energy conversion. There was no influence of the treatments on egg production (%) or egg mass (g/bird/day). Final weight and body weight change were significantly affected by increasing energy intake. Feed conversion ratio per egg mass, feed conversion ratio per dozen eggs and energy conversion significantly worsened as a function of the increase in daily energy intake. An energy intake of 280 kcal/bird/day with no addition of dietary oil does not affect layer performance.

Key Words: body weight change, egg production, lay percentage, layer nutrition

Introduction

Establishing the amount of feed intake is one of the main concerns of poultry nutritionists, considering that energy is the main factor that controls feed intake and that dietary energy represents a considerable part of costs with poultry feed (Penz Júnior & Pavan, 2007).

According to Tardin (1995), hens are able to control their feed intake, and consequently, their energy intake to supply their requirements for the accretion of muscles, bones, and feathers, and for egg production, as well as to replace losses associated with biosynthetic processes. Harms et al. (2000) mentioned that layers can cope better with a reduction than with an increase in dietary energy.

Although some studies have demonstrated that egg production is not affected by the dietary energy content (Harms et al., 2000), Valkonen et al. (2008) obtained higher egg production in layers fed energy-rich diets, and Faria & Silva (2004) observed that when energy intake is deficient, egg production is compromised.

Oil and fat sources have been widely used in broiler feeds to increase dietary energy density and to promote higher energy intake (Moura et al, 2003), but this practice has not been much studied in layers. According to Pinto et al. (2002), although fats increase feed palatability and reduce metabolic heat increment, feeds containing oil usually have higher metabolizable energy (ME) levels.

Costa et al. (2009) evaluated different soybean oil levels (1, 2 and 3%) and metabolizable energy levels (2600, 2750 and 2900 kcal/kg) in layer diets, and observed that the lowest energy level (2600 ME/kg) promoted the best utilization of energy, and consequently, of the other dietary nutrients. Those authors verified that the inclusion of up to 3% soybean oil was not sufficient to improve energy conversions, and therefore, no significant improvement in the utilization was obtained, as shown by the lack of effect on egg production or in the weight of the egg and its components (eggshell, yolk, and albumen).

According to Pinto et al. (2002), layers subjected to high environmental temperatures reduce their feed intake, and consequently, their production performance. Those authors used different levels of soybean soapstock (0, 1, 2, 3 and 4%) at an average temperature of 30.2 ºC and observed better performance at levels of 3% and higher compared with levels of 1 and 2%.

The objective of this study was to establish the best metabolizable energy intake (ME) for layers and the best level of addition of dietary vegetable oil to optimize layer performance.

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Material and Methods

In the experiment, 432 30-week-old Hisex Brown layers were distributed into 54 cages (1.00 m long, 0.45 m deep, and 0.40 m high), each housing eight birds. After the peak of laying, all birds were subjected to equal management and feeding and weighed to standardize the flock.

The nine experimental treatments were distributed according to a completely randomized experimental design in a 3 × 3 factorial arrangement, corresponding to three ME intake levels (280, 300 and 320 kcal/bird/day) and three dietary oil levels (0, 0.75 and 1.5 g/bird/day), with six replicates of eight birds each. In order to obtain the desired levels of ME and oil intake, feed intake levels were limited to 115 g (treatments 1, 4 and 7), 110 g (treatments 2, 5 and 8) and 105 g (treatments 3, 6 and 9) (Table 1).

Feedstuffs and feed samples were analyzed for dry matter, ash, crude protein, calcium and phosphorus levels (Table 2). The daily intake per bird of each nutrient of the experimental diets was estimated (Table 3).

Eggs from each replicate were collected daily and counted to determine egg production, and feed residues were weighed once weekly to determine feed intake. An experimental period of 20 weeks was considered for the analyses of the results.

Table 1 - Experimental treatments

Treatments	Energy intake, hen/day (kcal)	Oil intake, hen/day (g)	Feed intake, hen/day (g)
1	320	0.00	115
2	300	0.00	110
3	280	0.00	105
4	320	0.75	115
5	300	0.75	110
6	280	0.75	105
7	320	1.50	115
8	300	1.50	110
9	280	1.50	105

Average house temperature and relative humidity recorded during the experimental period were 22.8 °C and 74%, respectively.

The following parameters were evaluated: initial body weight, final body weight, weight gain, egg production, egg mass, feed conversion ratio per dozen eggs and per egg mass and energy conversion per egg mass.

The data obtained were analyzed using the command General Linear Models of statistical package SAS® (Statistical Analysis System, version 9.1). Parameters presenting normal distribution were subjected to analysis of variance, and when applicable, to orthogonal polynomial regression analysis.

Table 2 - Ingredients and calculated composition of the experimental diets

Ingredients	Treatments								
(%)	1	2	3	4	5	6	7	8	9
Ground corn	66.48	62.98	59.23	64.09	60.45	56.58	60.67	57.92	53.93
Soybean meal	17.27	19.10	20.96	16.90	18.76	20.63	17.57	18.45	20.24
Wheat bran	3.50	4.58	5.86	5.66	6.83	8.17	7.74	9.02	10.47
Meat meal	2.60	2.75	2.85	2.60	2.72	2.85	2.63	2.72	2.85
Soybean oil	-	-	-	0.65	0.68	0.71	1.33	1.36	1.44
Limestone	8.84	9.24	9.65	8.87	9.28	9.69	8.90	9.32	9.74
Dicalcium phosphate	0.69	0.71	0.78	0.62	0.64	0.70	0.55	0.56	0.65
Min/vit supplement[1]	0.26	0.27	0.28	0.25	0.27	0.28	0.25	0.27	0.28
Salt	0.26	0.27	0.28	0.26	0.27	0.28	0.26	0.27	0.28
Antioxidant	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
DL-methionine	0.09	0.09	0.10	0.09	0.09	0.10	0.09	0.10	0.11
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
				Composition					
ME (kcal/kg)	2,782	2,727	2,667	2,782	2,727	2,667	2,782	2,727	2,667
Crude protein (%)	15.65	16.36	17.14	15.65	16.36	17.14	15.65	16.36	17.14
Calcium (%)	3.65	3.82	4.00	3.65	3.82	4.00	3.65	3.82	4.00
Available phosphorus (%)	0.36	0.36	0.38	0.36	0.36	0.38	0.36	0.36	0.38
Methionine (%)	0.35	0.36	0.38	0.35	0.36	0.38	0.35	0.36	0.38
Methionine+cystine (%)	0.63	0.65	0.68	0.63	0.64	0.68	0.63	0.65	0.67
Lysine (%)	0.72	0.77	0.82	0.71	0.76	0.81	0.71	0.76	0.81

[1] Composition of the product per kg: vitamin A - 800,000 IU; vitamin E - 1,000 mg; vitamin K - 100 mg; vitamin B12 - 2,000 mcg; calcium pantothenate - 440 mg; niacin - 2,000 mg; choline - 50,000 mg; methionine - 160,000 mg; iodine - 60 mg; selenium - 20 mg; manganese - 6,000 mg; zinc - 10,000 mg; copper - 15,000 mg; iron - 10,000 mg; antioxidant - 125 mg; excipient qs. - 1,000 g.

ME: metabolizable energy; T1: energy intake - 320 kcal/hen/day; oil addition - 0 g; feed intake - 115 g; T2: energy intake - 300 kcal/hen/day; oil addition - 0 g; feed intake - 110 g; T3: energy intake – 280 kcal/hen/day; oil addition - 0 g; feed intake - 105 g; T4: energy intake - 320 kcal/hen/day; oil addition - 0.75 g; feed intake - 115 g; T5: energy intake - 300 kcal/hen/day; oil addition - 0.75 g; feed intake - 110 g; T6: energy intake - 280 kcal/hen/day; oil addition - 0.75 g; feed intake - 105 g; T7: energy intake - 320 kcal/hen/day; oil addition - 1.5 g; feed intake - 115 g; T8: energy intake - 300 kcal/hen/day; oil addition - 1.5 g; feed intake - 110 g; T9: energy intake - 280 kcal/hen/day; oil addition - 1.5 g; feed intake - 105 g.

Table 3 - Estimated daily intake of each nutrient

Nutrients	Treatments								
	1	2	3	4	5	6	7	8	9
ME (kcal/kg feed)	320	300	280	320	300	280	320	300	280
Oil intake (g/day)	0.00	0.00	0.00	0.75	0.75	0.75	1.5	1.5	1.5
Crude Protein (g/day)	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
Calcium (g/day)	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20
Avail. Phosphorus (g/day)	0.41	0.40	0.40	0.41	0.40	0.40	0.41	0.40	0.40
Methionine (g/day)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Met + cys (g/day)	0.73	0.72	0.71	0.72	0.70	0.71	0.72	0.71	0.71
Lysine (g/day)	0.83	0.85	0.86	0.82	0.84	0.85	0.81	0.83	0.85
Supp. (g/day)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Salt (g/day)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30

ME - metabolizable energy.

Results and Discussion

There was no interaction between soybean oil and energy intake for any of the parameters evaluated, which shows that the main factors did not interfere with each other, and therefore, their effects were studied separately.

No significant differences in initial body weight were observed. There was no effect of oil intake on any of the parameters evaluated (Table 4). Daily energy intake significantly influenced both final weight and body weight change, which improved as the energy intake increased.

When the regression equations for final weight and body weight change are applied, a significant increasing linear effect linear is observed, as shown below:

Y= 2.7313X + 1141, R^2=0.8685, in which: Y = final weight and X = ME intake.

Y= 2.6235X - 816.88, R^2=0.7418, in which: Y = body weight change and X = ME intake.

These results are consistent with the findings of Lewis et al. (1994), who fed layer diets containing 2600 or 3080 kcal ME/kg feed and observed an increase in body weight gain during laying as the dietary energy level increased.

The higher final body weight resulting from the increase in dietary ME was also obtained by Attia et al. (1995), Rosa et al. (1997) and Xavier & Peixoto (1997), who fed layers with diets with increasing ME levels and concluded that increasing the dietary energy density increases body weight. On the other hand, Araújo & Peixoto (2005), as well as Jalal et al. (2006), did not find any significant differences in the body weight of young layers (20 to 35 weeks of age) fed increasing metabolizable energy levels.

The results obtained in the present experiment with dietary oil addition are consistent with those of Shafey et al. (1992), who fed three different layer strains with diets with the same amount of calories, containing different cereals and with or without the addition of 2% of soybean oil, and did not find any significant effect (P>0.05) on body weight gain.

On the other hand, Keshavarz & Nakajima (1995) fed layers with diets supplemented with animal fat, corn oil or

Table 4 - Initial body weight, final body weight and weight change of hens subjected to the experimental treatments

Parameters	Oil intake (g/hen/day)	Energy intake (kcal/hen/day)			Mean	CV (%)
		280	300	320		
Initial weight (g)	0.00	1992	2002	1990	1995	
	0.75	1963	2006	1988	1986	2.90
	1.50	1991	1995	1981	1989	
	Mean	1982	2001	1986		
Final weight (g)[1]	0.00	1927	1933	2055	1971	
	0.75	1899	1942	2012	1952	4.95
	1.50	1926	1932	2014	1957	
	Mean	1918	1936	2027		
Weight change (g)[1]	0.00	-64.55	-69.17	64.42	-23.10	
	0.75	-63.58	-64.35	24.35	-34.53	2.62
	1.50	-65.12	-63.15	32.80	-31.83	
	Mean	-64.42	-65.56	40.52		

[1] Significant linear effect (P<0.05) for daily metabolizable energy intake.
CV - coefficient of variation.

a mixture of both at levels of 0, 2 and 4% and concluded that weight gain between 18-38 weeks was significantly influenced by fat addition, with those fed the oil-fat mixture presenting higher weight gain than those fed 2% animal fat. Grobas et al. (1997) also studied the effect of dietary fat supplementation and different energy levels in layer diets, and concluded that high energy and fat diets increase energy intake and body weight.

There was no influence of the treatments on egg production (Table 5). Similar results were also obtained by Costa et al. (2004), Wu et al. (2007), Jalal et al. (2007) and Costa et al. (2009), who fed layers with different ME levels and concluded that the dietary energy level did not cause any significant effect (P>0.05) on egg production. However, Araújo & Peixoto (2005) observed instead a reduction in egg production (P<0.05) as the dietary energy level increased, whereas Valkonen et al. (2008) obtained an increase in egg production with increasing dietary energy levels; however, the latter worked with energy levels lower than those used in the present study and those recommended in the literature (2345 to 2629 kcal ME/kg feed). These controversial results may be explained by the fact the energy levels higher than those recommended do not increase production, while energy deficiency decreases production.

There was no influence of energy and oil levels on egg mass, as previously observed by Jalal et al. (2007), Valkonen et al. (2008) and Costa et al. (2009), who fed layers with diets containing different energy levels and also did not find any effect on egg mass. However, Wu et al. (2007) observed an increase in egg mass as the dietary ME level increased.

In relation to the addition of oil to the feed, the results of the present study are consistent with those of Costa et al. (2009), who compared diets with the inclusion of 1, 2 and 3% soybean oil and concluded that there was no significant effect of the treatments on egg mass. Parsons et al. (1993) fed layers with diets containing different protein levels and the addition of 0, 2, 4 or 6% corn oil and obtained significantly higher (P<0.05) egg production and egg mass with the addition of oil to the diet. This may be explained by the possible dietary deficiency of essential fatty acids, which were supplemented by the addition of oil to the diet, with consequent improvement of egg weight, and hence, egg mass.

Feed conversion ratio per egg weight (FCR/kg) and per dozen eggs (FCR/dz) were significantly impaired (P<0.05) as the energy intake increased. Treatments presented an increasing linear effect (P<0.05) on these parameters, and are expressed in the following equations $Y=0.0034X + 1.2231$, $R^2 = 0.9996$, in which Y = feed conversion ratio/mass and X = energy intake for FCR/kg, and $Y = 0.0036X + 0.5671$, $R^2 = 0.9972$, in which Y = feed conversion ratio per

Table 5 - Egg production, egg mass, feed conversion ratio/kg eggs (FCR/kg), feed conversion ratio/dozen eggs (FCR/dz) and energy conversion/kg eggs (EC/kg) of hens subjected to the experimental treatments

Parameters	Oil intake (g/hen/day)	Energy intake (kcal/hen/day)			Mean	CV (%)
		280	300	320		
Egg production (%)	0.00	81.38	81.24	81.22	81.28	
	0.75	80.84	82.86	87.15	83.65	4.30
	1.50	82.78	83.06	82.38	82.74	
	Mean	81.70	82.38	83.58		
Egg mass (g/hen/day)	0.00	49.32	49.64	47.67	48.88	
	0.75	48.36	48.89	53.12	50.12	5.17
	1.50	48.96	50.06	50.32	49.78	
	Mean	48.88	49.53	50.37		
FCR/kg[1]	0.00	2.16	2.22	2.43	2.27	
	0.75	2.18	2.27	2.18	2.21	5.36
	1.50	2.16	2.21	2.29	2.22	
	Mean	2.16	2.23	2.30		
FCR/dz[1]	0.00	1.57	1.63	1.71	1.63	
	0.75	1.56	1.60	1.59	1.59	4.41
	1.50	1.53	1.60	1.68	1.60	
	Mean	1.55	1.61	1.66		
EC/kg[1]	0.00	5.80	6.06	6.76	6.20	
	0.75	5.81	6.20	6.06	6.02	5.41
	1.50	5.75	6.01	6.38	6.04	
	Mean	5.79	6.09	6.40		

[1] Significant linear effect (P<0.05) for daily metabolizable energy intake.
CV - coefficient of variation,

dozen eggs and X = energy intake for FCR/dz. This may be explained by the higher feed intake of the birds fed higher energy levels, according to the experimental treatments.

The results of the present experiment disagree with the findings of Grobas et al. (1999), Wu et al. (2007) and Valkonen et al. (2008), who fed layers different dietary ME levels and observed an improvement ($P<0.05$) in feed conversion ratio as the dietary ME increased. On the other hand, Grobas et al. (1999) and Costa et al. (2004) evaluated the effect of the intake of feeds containing different energy levels on the egg production of layers and concluded that feed conversion ratio was not influenced ($P>0.05$) by the dietary energy level; however, feed was offered *ad libitum* in these experiments. The differences in feed conversion ratio results per kg and per dozen eggs may be due to the energy levels used in the different studies because, when energy supply is higher than the nutritional requirements of birds, there are no improvements in egg production, egg mass or feed conversion ratio; however, the energy surplus may be stored in the body, increasing body weight and body fat content. The study of Costa et al. (2009) must also be mentioned; the authors worked with three energy levels (2600, 2750 and 2900 kcal ME) and a feed intake limited to 120 g/bird/day and did not find any effect on feed conversion ratio, which may be a result of establishing the same feed intake for the different energy levels.

No effects of addition of oil to the diet on feed conversion ratio per dozen eggs or per egg mass were observed. These results are in agreement with those of Kling & Hawes (1990), Reddy et al. (1991) and Costa et al. (2009), who compared feeds with different oil levels and concluded that oil inclusion did not influence feed conversion ratio.

Energy conversion per kg eggs worsened ($P<0.05$) as a function of daily energy intake, with an increasing linear effect, as shown by the equation: $Y = 0.024 X – 0.9947$, in which: Y = energy conversion and X = energy intake, with $R^2 = 0.9371$. These results indicate that the energy intake of 280 kcal/bird/day supplied the energy requirements for maintenance and production of the experimental birds. Araújo & Peixoto (2005) and Costa et al. (2009) also found a significant linear effect on energy conversion, which worsened as the dietary energy level increased. Conflicting results were observed by Jalal et al. (2006) and Valkonen et al. (2008), who did not find any significant difference in energy conversion. No effect of oil addition on energy conversion per kg eggs was detected, which was also found by Costa et al. (2009) when feeding different oil levels to brown layers. No influence of the dietary inclusion of up to 3% oil on energy conversion per dozen eggs and per egg mass was found.

Conclusions

Under the conditions of the present study, and according to the results obtained, the dietary energy level of 280 kcal/bird/day with no oil addition may be used for brown layers with no effect on their performance.

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