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Dietary energy of guinea fowl on laying performance and biochemical hematological parameters

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ABSTRACT

The energy level is one of the main food components that greatly impact the production and reproductive performance of laying poultry. The increase of the energy in the breeding hen meal raises the laying rate and reduced the mean egg weight. The purpose of this study was to assess the effects of variation in energy intake on indigenous guinea fowl breeder's performances. A total of 168 females and 84 males fed since day old with 3 diets: Control, Poor energy (Poor-E), and Rich energy (Rich-E) were crossed at 23rd week old with a sex ratio of 2 females for 1 male. From the 32nd to the 39th week of age, 32 eggs per group were randomly taken to assess their external and internal quality. Blood samples were collected from all groups at the 22nd and 60th week of age for hematology and biochemical parameters assay. The data were processed by Graph Pad Prism 5.00.288 software and the ANOVA test was used for analysis. The means were compared by the Tukey HSD test and $p<0.05$ was considered as the significance threshold. The results showed that the guinea fowls fed Rich-E consumed (88.43±0.28g/j) less feed ($p<0.05$) than those of the control group (91.88±0.61g/j). Poor-E raised ($p<0.05$) egg weight (39.33g vs 38.46g). However, this diet decreased the laying rate (47.92% vs 50.35%). The Rich-E diet reduced ($p<0.05$) the laying rate (33.5% vs 50.35%), and the egg weight (35.75g vs 38.46g). Hematocrit of Rich-E is significant ($p<0.05$) less than those of the control group. The serum total protein and albumin levels were higher ($p<0.05$) in Poor-E than those of the control group. This study showed that Poor-E diets improved laying rate, and egg weights.

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1. INTRODUCTION

Diet is one of the main environmental factors influencing poultry performance under intensive or traditional farming. The food of pullets and then hens has a significant influence on egg mass via the number or weight of eggs. (Yu et al. 1992) reported that in immature females, a large body weight is often the consequence of excessive consumption compared to their needs, which causes accelerated development of the reproductive system at sexual maturity and ovarian hyperactivity. The energy level is one of the main food components that greatly impact the production and reproductive performance of laying poultry. Larbier and Leclercq (1992) showed that increasing the energy in the breeding hen meal raises the laying rate. The disruption of energy intake leads to ovulation disorders through functional alterations of the hypothalamic-pituitary system and particularly the secretion of luteinizing hormone (Briere et al., 2011). According to Cheng (1991), a higher energy content (+215 Kcal/kg from 0 to 6 weeks and +357 Kcal/kg from 6 to 18 weeks) reduced the mean egg weight (55.0 vs 56.1 g) in the hen from 20 to 64 weeks.

On the other hand, during laying, an enhancement in energy intake raises egg weight (Leeson et al., 2001 ; Valkonen et al., 2008). However, excess energy reduces the production of functional oocytes by causing the deregulation of the follicular hierarchy (Renema et al., 1999). This deregulation leads to multiples or closed ovulations, giving rise to abnormal eggs or eggs with double yolks (Walzem et al., 1993). In guinea fowl, Nahashon et al. (2007) reported that a diet of 3000 - 3100 kcal/kg ME with 22 - 24% crude protein (CP) at 0 - 8 weeks of age; 3100 - 3200 kcal/kg ME with 19 - 21% CP at 9 - 16 weeks of age and 2800 kcal/kg ME with 14% CP at lay improves egg production, egg weight, feed conversion ratio, internal egg quality at 28 - 56 weeks and 62 - 86 weeks. In tropical environments, scientific data are scarce on the nutritional needs of local guinea fowls. The rare few studies are limited to the juvenile age of the birds. It is, therefore, essential to evaluate the effects of the variation in the dietary energy composition on the performances and the biochemical and hematological parameters of the local guinea fowls.

2. METHOD

2.1 Experimental design

One hundred sixty-eight females and eighty-four cocks of local guinea fowls fed from day old with 3 different diets: Control, Poor-E, and Rich-E according to their age, were selected and crossed at 23rd week of age with 4 replicates for 2 females to 1 male of sex ratio. The feedstuffs and calculated nutritive values of diets are shown in Table 1. All groups were subjected to the same prophylactic program and the birds had free access to feed and water throughout the experiment. Feed intake and egg production collected in the 28th week were the starting data. These breeders were weighed at the start and end of the lay. Eggs laid were collected daily. From the week 32 to 39 of age, a sample of 32 eggs per group was randomly chosen, weighed, and then broken to assess their internal and external quality. Blood samples were collected from all groups at the 22nd and 60th week of age for hematology and biochemical parameters analysis.

Table 1. Diets composition and macronutrient levels according to treatment and age

	Starter (1-8 weeks)			Growth (9-22 weeks)			Laying (23-60 weeks)		
Ingredients (%)	Control	Poor-E	Rich-E	Control	Poor-E	Rich-E	Control	Poor-E	Rich-E
Maize	32	21	40	53	50	57	57	52	61
Wheat	10	10	5	17	20	11.5	10.5	17	7
Soybeans	25	19	26	15.5	10	17	17	15.5	21.5
Dresh	5	8	3	-	-	-	-	-	-
Fish	7	11	8	5	9	5	5	6	2
Millet	15	22	12	-	-	-	-	-	-
Flesh concentrated	5	8	5	5	6.5	5	-	-	-
Laying concentrated	-	-	-	-	-	-	4	3	2
Shell	1	1	1	4.5	4.5	4.5	6.5	6.5	6.5
Total	100	100	100	100	100	100	100	100	100
Analysis									
ME (kcal/kg)	2894	2791	2991	2757	2663	2848	2802	2701	2906
Crude protein	21.34	21.39	21.59	18.04	18.4	18.19	17.13	17.16	17.10
Calcium	0.94	1.14	0.98	1.84	2.04	1.86	2.54	2.50	2.30
Phosphorus	0.78	0.97	0.72	0.73	0.88	0.69	0.70	0.73	0.52
Methionine	0.49	0.62	0.52	0.45	0.52	0.45	0.09	0.09	0.10
Lysine	1.1	1.23	1.20	0.93	1.03	0.93	0.36	0.36	0.43
Methionine + cysteine	0.75	0.90	0.77	0.67	0.76	0.67	0.19	0.20	0.21

Poor-E: Poor Energy, Rich-E: Rich Energy

2.2 Determination of some parameters

$$\text{Laying rate (\%)} = \frac{\text{Sum of eggs laid during a week}}{\text{Number of guinea fowl} \times 7} \times 100 \quad (1)$$

$$\text{FCR} = \frac{\text{Daily feed consumption}}{\text{Laying rate} \times \text{Average egg weight}} \times 100 \quad (2)$$

$$\text{The proportion of albumen} = \frac{\text{Absolute albumen weight}}{\text{Absolute egg weight}} \times 100 \quad (3)$$

$$\text{Yolk proportion} = \frac{\text{Absolute yolk weight}}{\text{Absolute egg weight}} \times 100 \quad (4)$$

The Haugh unit was calculated using the method of Haugh (1937) through the following formula:

$$HU = 100 \times \log (H - 1.7W0.37 + 7.6) \quad (5)$$

Where HU = Haugh unit; H = height of blank; W = egg weight

2.3 Total proteins, albumin, triglycerides, and cholesterol levels determination

At 22nd and 60th of age, blood samples were collected from six guinea fowl hens from each replicate for the triglycerides, cholesterol, total protein, and albumin determination. These parameters were determined by using an enzymatic colorimetric method on 10, 3, 10, and 10 µl of serum, respectively for the triglycerides, cholesterol, total protein, and albumin. This process is based on the coloration formation which the intensity is proportional to the concentration of the parameter. To approve the test, a classic was tested and the optical density measurements were made at 490, 500, 546, and 630 nm respectively for the triglycerides, cholesterol, total protein, and albumin, according to the protocols of Cypress Diagnostics.

2.4 Hematology determination

The blood was collected from six guinea fowl hens per replicate into EDTA tubes to determine the hemoglobin, red blood cells, hematocrit, white blood cells, and lymphocytes by utilizing ABX Micros 60 method. This process is a fully automated hematology analyzer according to (Nakul-Aquaronne et al., 2003) method.

2.5 Statistical analysis

All data were analyzed by Graph Pad Prism 5.00.288, a California software (Morgan, 1998). ANOVA one-way test was used to analyze the variance. Means were compared using TUKEY's test when the means of the general model were statistically different. The Chi-square test was used to compare the laying rate. The probability $p < 0.05$ was retained as the significance threshold

3. RESULTS AND DISCUSSION

3.1 Age at the start of lay, live weight at the start and end of lay, feed intake, feed conversion ratio, laying rate, and average egg weight

The reduction of 101 kcal/g in the energy level of the feed significantly raised ($p < 0.0001$) the feed ingestion of the breeding guinea fowls. In contrary, the enhancement of 107 kcal/g decreased the feed intake level (Table 2). This can be explained according to Larbier and Leclercq (1992), that the guinea fowl regulates its feed intake to meet its energy needs. Thus, poultry consumed less if the feed covers more of its nutritional needs, especially energy, and vice versa.

The table 2 showed that the energy level influences body weight. Thus, the breeders of the Poor-E group presented maximum body weight ($p < 0.0001$) at the start and end of laying compared to that of the control group; but, the Rich-E group presented a lightweight body ($p < 0.0001$). This result would be due to the augmentation in the feed intake of the birds of Poor-E group. Indeed, by consuming more feed to satisfy their energy needs, the guinea fowls of this group ingested more protein which is an essential element in the formation and development of muscles.

Table 2. Effect of dietary energy manipulation on the performance of guinea fowl

Parameters	Control	Poor-E	Rich-E	p-value
Feed intake (g/d)	91.88 ± 0.61^b	110.30 ± 0.37^a	88.43 ± 0.28^c	<0.0001
Live weight at the start of lay (g)	1377 ± 23.76^b	1445 ± 27.78^a	1278 ± 23.79^c	<0.0001
Live weight at the end of lay (g)	1519 ± 25.70^c	1682 ± 35.00^b	1363 ± 33.76^d	<0.0001
Age of onset of lay (week)	26.00±0.71	26.00±0.71	27.25±0.25	0.3457
Egg-laying rate (%)	50.35 ± 2.75^b	47.92 ± 3.14^a	33.50 ± 2.09^c	<0.0001
Average egg weight (g)	38.34 ± 0.23^c	39.22 ± 0.22^b	35.51 ± 0.23^d	<0.0001
Feed conversion ratio	3.92 ± 0.35^b	6.08 ± 0.56^a	4.40 ± 0.43^b	<0.0001

^{a,b,c}: Different superscripts in the same row indicate significant differences (p<0.05). Poor-E: Poor Energy, Rich-E: Rich Energy.

The enhancement or reduction in the energy concentration of the feed of breeding guinea fowls did not influence (p=0.3457) the age of onset of lay (Table 2). This result would be due to the small difference in variation of the energy level in their feed rations which did not create a great difference between their weight growth and their ovarian development.

The laying rate was lower (p<0.0001) in the birds of the Rich-E group compared to the control. This result is contrary to the conclusion of Larbier and Leclercq (1992) which, the increase in metabolizable energy in the feed of the hens increases the laying rate. The birds that consumed the Poor-E diet had the heaviest eggs (p<0.0001), while the eggs of birds fed with the Rich-E feed were lighter (p<0.0001) compared to those of the control. This increase in egg weight of Poor-E group could be due to the large amount of protein ingested by these birds. Indeed, the low energy level contained in their ration led these guinea fowls to overconsume the feed to meet their energy needs. By increasing their feed intake, they have therefore ingested enough protein and which, according to Van Krimpen et al. (2008) is a determinant of the average egg weight of poultryThe lightweight of Rich-E eggs is attributable to the low amount of protein ingested This result is contrary to the conclusion of Wu et al. (2007), which indicate that egg weight enhances with increasing feed energy level van Emous et al. (2015) reported that increasing the energy level in broiler breeder feed did not influence egg weight. As for the feed conversion ratio, it was higher in the Poor-E compared to that of the Rich-E and control group. This augmentation would be to the consequence of feed overconsommation of the birds of Poor-E group.

3.2 Egg length, egg breadth and egg form index

The egg length, egg breadth and egg form index of Rich-E group breeder were smaller (p<0.0001) than that of eggs from Poor-E and Control groups. This would be the significantly lightweight of breeders of this Riche-E group. Because it demonstrated that the small bird lay a small egg and vice versa. This result is contrary to the conclusion of Harms (1992) and Wu et al. (2007) Wu et al. (2007), which indicate that egg weight enhances with increasing feed energy level.

Table 3. Effect of dietary energy manipulation on the performance of guinea fowl

Parameters	Control	Poor-E	Rich-E	p-value
Egg length (mm)	47.40±0.42^{a}	47.06±0.30^{ab}	45.64±0.46^{b}	0.0114
Egg breadth (mm)	35.71±0.16^{b}	36.91±0.20^{a}	34.04±0.29^{c}	<0.0001
Form index	78.00±0.76^{ab}	77.89±0.23^{ab}	74.61±0.47^{c}	<0.0001

^{a,b,c}: Different superscripts in the same row indicate significant differences (p<0.05). Poor-E: Poor Energy, Rich-E: Rich Energy.

3.3 The proportion of albumen, Yolk, and Shell and Haugh Unit

The proportions of albumen were similar (p>0.05) in all groups (Figure 1a). The feed of the breeding guinea fowls did not affect the proportion of yolk because these different proportions were similar in all groups (Figure 1b). In contrary, Rao et al. (2009) and Bouvarel et al. (2010) found that the composition and structure of the egg can be modified by maternal nutrition.

The proportion of the shell was weak in the Rich-E group (p<0.05) compared to that of the control group (Figure 1c). In the same direction, the work of Adeyemo and Longe, (1996) on the effects of iso-proteins with different energy levels (2400, 2500, 2600, and 2700 kcal/kg ME) found that the weight of the shell was not impacted.

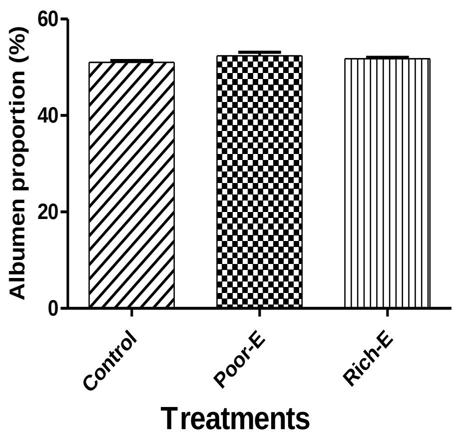

Figure 1a: Egg albumen proportion

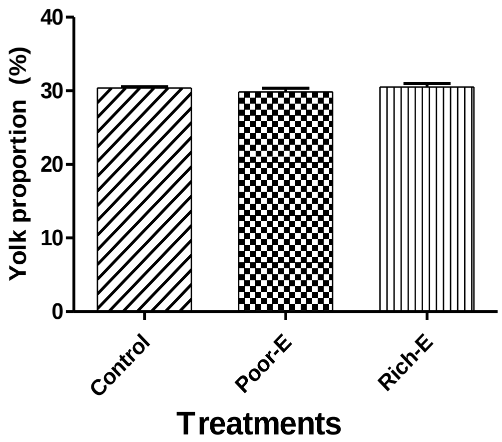

Figure 1b: Egg yolk proportion

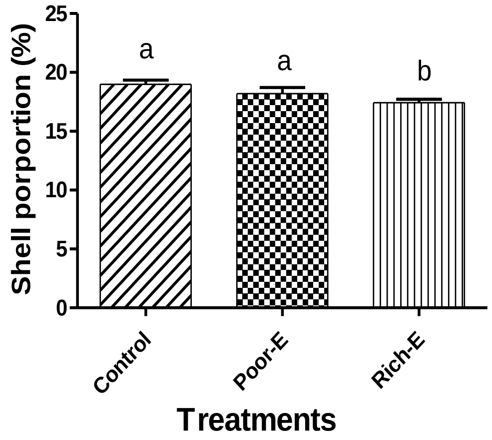

Figure 1c: Eggshell proportion

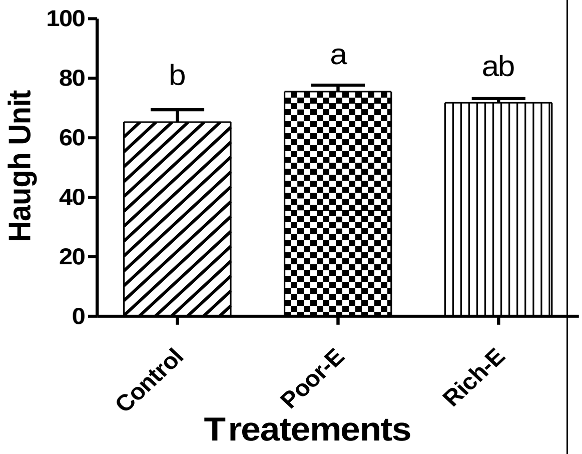

Figure 1d: Egg Haugh unit

^{a,b,c} Different superscripts in the same row indicate significant differences ($p<0.05$). Poor-E: Poor energy, Rich-E: Rich Energy

The reduction in energy level increased the Haugh Unit compared to the control (Figure 1d). It reflecting the improvement in the quality of the thick white and by extension, the quality of the eggs of the breeders of this group. Indeed, the thick white of the egg is composed mainly of protein. On the other hand, the Haugh unit of eggs from breeding local guinea fowls was not affected by the Rich-E treatment. Similarly, Junqueira et al. (2006) also found no difference between the Haugh units of eggs from Isa-Brown laying hens by varying the energy content (2850 to 3050 kcal/kg ME) of their feed.

3.4 Hematology of guinea fowl at the start and end of lay

The reduction in the level of dietary energy, led to a increase in the red blood cells, hemoglobin, and hematocrit concentrations (Table 4). This increase would be due to the high concentration of serum albumins which are involved in the storage of amino acids in poultry. So these birds have nutrients for the synthesis of protein compounds.

Table 4. Red blood cells, white blood cells, hemoglobin, hematocrit and lymphocytes of guinea fowl at the start and end of lay

Parameters	Weeks	Control	Poor-E	Rich-E	p-value
Red blood cells (x109 /l)	22	2.76±0.11	2.81±0.16	2.74±0.11	0.8259
	60	2.98±0.09^{a}	3.04±0.05^{a}	2.73±0.04^{b}	0.0071
Hemoglobin (g/dl)	22	18.66±0.51^{a}	18.20±0.40^{a}	16.38±0.60^{b}	0.0007
	60	22.30±0.75^{a}	22.90±0.86^{a}	19.22±0.41^{b}	0.0035
Hematocrit (%)	22	34.95±0.72	35.42±0.70	31.71±0.73	p<0.0001
	60	47.92±1.22^{a}	48.72±1.11^{a}	41.18±1.60^{b}	0.0014
White blood cells (x1012/l)	22	69.31±8.35^{b}	74.20±1.04^{b}	90.07±1.87^{a}	0.0023
	60	65.42±2.24	59.65±2.60	66.11±2,58	0.1578
Lymphocytes (x109 /l)	22	66.25±0.91^{b}	60.28±2.28^{b}	88.79±2.23^{a}	p<0.0001
	60	59.87±2.54	61.45±2.21	60.48±1.61	0.8721

^{a,b,c}: Different superscripts in the same row indicate significant differences ($p<0.05$). Poor-E: Poor Energy, Rich-E: Rich Energy

The guinea fowl of Rich-E group have got high white blood cells level and lymphocytes level which means that these subjects are immunocompromised (Table 4).

3.5 Serum concentrations of total protein, albumin, total cholesterol, and triglycerides of local guinea fowl at the start and end of lay

The Poor-E group had a higher level ($p<0.05$) of total proteins and serum albumin compared to that of the control group. On the other hand, the total proteins and serum albumin of the birds of the Rich-E group were statistically smaller ($p<0.05$) compared to the control group. This is due to the fact that energy is converted into fatty compounds in the event of excess energy but in the event of a drop in energy there will be a conversion of energy into glucoforming amino acids, hence the increase in serum proteins (Table 5).

Table 5. Serum concentrations of total protein, albumin, total cholesterol, and triglycerides of local guinea fowl at the start and end of lay

Parameters	Weeks	Control	Poor-E	Rich-E	p-value
Total protein (g/l)	22	31.49±0.98[b]	34.61±0.29[a]	28.82±0.55[c]	p<0.0001
	60	29.96±0.38[b]	33.75±0.60[a]	27.71±0.39[c]	p<0.0001
Albumin (g/l)	22	16.49±0.46[a]	17.95±0.12[a]	15.02±0.50[b]	0.0005
	60	18.03±0.21[a]	19.63±0.24[a]	15.80±0.40[b]	p<0.0001
Total cholesterol(g/l)	22	1.31±0.05[b]	1.58±0.07[a]	1.66±0.07[a]	0.0034
	60	1.54±0.06[b]	1.87±0.04[a]	1.86±0.05[a]	0.0005
Triglycerides (g/l)	22	0.83±0.20	0.64±0.08	0.60±0.12	0.4637
	60	0.52±0.22[b]	0.74±0.06[a]	0.76±0.06[a]	0.0099

[a,b,c]: Different superscripts in the same row indicate significant differences (p<0.05). Poor-E: Poor Energy, Rich-E: Rich Energy

The cholesterols and triglycerides of the Poor-E and Rich-E groups were superior (p<0.05) compared to the control groups. The enhancement or diminution in the level of feed energy led to an increase in the serum concentration of total cholesterol. According to Nideou (2018), this result is attributable to the conversion of energy into lipids when the energy contained in the feed satisfies the needs for growth and production. Indeed, the overconsumption of the Poor-E diet by the breeders of the Poor-E group would have allowed significant ingestion of energy than those of the Rich-E group, which provided them with significant energy more than their need (Table 5).

4. CONCLUSION

The different energy level variations impacted local guinea fowls' laying performance. Thus, the reduction in the energy concentration harmed the level of feed intake, and the laying rate giving rise to an enhancement in the feed conversion ratio in the guinea fowls of this group. However, this drop in dietary energy level resulted in improved egg weight. Nevertheless, the increase in the dietary energy level of guinea fowl breeders caused a decrease the egg laying, weight, and egg size. Future research is recommended to explore the interaction between energy levels and other nutrients such as protein, essential amino acids, and micronutrients, to optimize feed composition more efficiently and economically.

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