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Effect of High Levels of Dietary Energy on the Performance of Laying Hens Under Hot Climates

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ABSTRACT

The effect of increasing dietary energy by using corn oil on the performance of Bovans White Leghorn hens under high environmental temperatures was studied. Five replicate groups of eight hens, 25 wk of age, housed two per cage, were randomly assigned to each of four different energy treatments. Mean temperatures recorded daily at 7a.m and 1p.m. were 260C and 320C, respectively; mean relative humidity recorded daily at 7a.m. and 1p.m. was 56 and 47, respectively. The basal corn-soybean meal layer diet contained 17.5% CP, 2.8Mcal ME/kg, 3.5% Ca, and 50% available P. Treatments consisted of feeding on an ad libitum basis the basal diet alone or with graded levels of corn oil to provide increases of 5, 10, and 15% ME. Freed intake, body weight, hen-day egg production, egg weight, Haugh unit scores, and egg shell thickness were measured every 28 days. The experiment was conducted for 44 wk. Hens fed diet containing corn oil showed a significant reduction ($P<.05$) in feed intake compared to hens fed the basal diet at the end of the 2nd and 3rd periods. A 5% increase in ME of hens dietary energy numerically improved egg production and food conversion ratio throughout the trial, and significantly improved egg production, hen-day egg mass production, and feed conversion ratio at the 11th period. Egg weight was significantly reduced at the 3rd, 4th, and 7th periods by increasing dietary energy by 10%. The addition of 15% dietary corn oil significantly improved egg shell thickness during the 5th and 10th periods.

Key words : Climate, egg production, energy, laying hens, temperature

INTRODUCTION

For the last two decades, the poultry industry in the United Arab Emirates (U.A.E.) has been growing exponentially to meet the higher demand for poultry products (meat and eggs) in this Gulf state. However, meat and egg producing farms have continuously been affected by the high environmental temperature in this region. Previous records showed average temperatures of 18 to 26°C during January through April, 32 to 35°C during May through August, and 33 to 20°C during September through December in the Al-Ain area of the U.A.E. According to North and Bell (1990) chicken feed consumption decreases by about 1% for every 1°F increase in environmental temperature. As the level of dietary energy increases, hens tend to decrease their feed intake. High environmental temperature in temperate regions can cause heat stress. This, in turn, affects the performance of laying hens and can result in reduced egg production and lower egg quality, and consequently, large economic loss.

Although it has been well known for years that the performance of laying hens drops at higher constant temperatures (Miller and Sunde, 1975; De Andrade et al., 1977; Engster and Snetsinger, 1980; Paguri and Coon, 1993), the effect of environmental cyclic temperatures on performance is still not clear. Miller and Sunde (1975), in a laying hen study, found that egg production was reduced for hens raised under constant high temperature (32°C) compared to hens raised under cycling high temperatures (26 and 38°C). Paguri and Coon (1993) reported that feed intake of laying hens was significantly reduced in hot climates. They also found that egg mass production was optimum at 23.9°C compared with an environmental temperature of 33.9°C. Diambra et al. (1993) conducted a study to assess the calorie/protein requirements of laying hens raised under tropical conditions, and found that birds receiving the high calorie/low-protein diet performed better in all groups. They concluded that a diet consisting of lower protein and higher energy in the form of supplemental fat improved the birds' comfort, and hence, performance under tropical environmental conditions.

In broiler studies, it was reported that the addition of 5% corn oil to either a conventional broiler diet or a low-protein diet did not alleviate the negative effect of high constant temperature. Also, it was found that constant high temperature (32°C) significantly reduced all production parameters compared to cyclic (17 to 30^{0}C) temperatures (Istaytiyyah, 1987). Dale and Fuller (1979) noted that replacing corn starch calories with fat calories did not result in the expected 10% decrease in feed intake of broilers raised in either hot or cold temperatures. Also, heat production was found to be lower in chicks fed diets with the high ratio of fat to non-fat calories. Diab et al. (1987) found that birds performed better when fed a high energy diet (containing 4.5% oil) under constant high ambient temperature (36^{0}C).

Reid and Weber (1973), reported that energy was the most limiting factor associated with egg production for hens raised under heat stress. Also, it is known that nothing alters caloric intake more than changes in the environmental temperature (North and Bell, 1990).

To date, practically nothing has been published on laying hen nutrition in relation to heat stress under the climatic conditions of the Gulf region. It was, therefore, of interest to study the effect of feeding graded levels of dietary energy on the performance of laying hens under the environmental temperatures in the U.A.E.

MATERIALS AND METHODS

White Leghorn hens (Bovans) were used in this experiment. Five replicate groups of eight hens, 25 wk of age, housed two per cage (45 cm wide x 50 cm long x 45 cm high) in a closed house, were randomly assigned to each of four different dietary energy treatments. The dietary treatments consisted of feeding a basal corn-soybean meal layer diet (Table 1) alone or with graded levels of corn oil to provide an increase in energy content of 5, 10, and 15% ME. The calculated nutrient composition of the basal diet, based on ingredient composition tables (Scott et al., 1982) is shown in Table 1. Feed and water were provided ad libitum. Feed intake, body weight, egg weight, Haugh unit scores, and egg shell thickness were measured every 28 days. Hen-day egg production was measured daily. A daily lighting program consisting of 16h of L and 8h of D was used. The experiment ran for 44 wk. Temperature and relative humidity of the house were recorded daily at 7:00 a.m. and 1:00 p.m., and the means were calculated every 28 days (Table 2).

Statistical analyses were performed using the general linear models (GLM) program (SAS, 1982). Differences among treatment

Table 1. Composition of basal diet

Ingredient	%
Ground yellow corn	66.70
Dehulled soybean meal (48 % CP)	18.15
Meat and bone meal	5.90
Salt	.35
Ground limestone	6.50
Ground oyster shell	.70
Dicalcium phosphate (22% Ca, 18.5% P)	.60
Vitamin-mineral premix[1]	1.00
Dl-Methionine (99%)	.10
Calculated Nutrient composition	
ME, mcal/kg	2.80
Protein %	17.50
Calcium %	3.56
Phosphorus, available %	.52
Lysine %	.84
Methionine %	.38
Methionine + Cystine%	.68

[1]Provided the following per kilogram diet: Vitamin A, 12,000 IU; Vitamin D3, 2,000 IU; vitamin E, 10 IU; menadione dimethylpyrimidinol bisulfite, 2mg; riboflavin, 2.2 mg; pantothenic acid, 7.5 mg.

Table 2. Average air temperature and relative humidity inside laying hens house

Period[1]	Temperature, (°C) 7:00 a.m	R.H.[2] 7:00 a.m.	Temperature (°C) 1:00 p.m.	R.H.(%) 1:00 p.m.
1	21	48	28	32
2	24	40	32	27
3	26	36	32	30
4	25	54	33	56
5	30	50	35	38
6	31	70	34	58
7	30	71	34	58
8	28	61	32	50
9	25	58	30	57
10	22	59	28	56
11	18	69	26	48

1period = 28 days
2 R.H. = Relative Humidity

means were separated by using the test of least significant difference (Snedecor and Cochran, 1980). A probability level of <.05 was used for statistical significance.

RESULTS

The results of feeding graded levels of dietary energy on body weight, feed intake, egg production, and egg weight of WL laying hens are shown in Table 3. No significant effects on body weight were observed throughout the duration of the experiment. Feed intake was significantly ($p < .05$) reduced during the 2nd period only for hens fed the basal diet + 5% ME. However, in the 3rd period hens fed diets supplemented with 10 and 15% ME showed a significant reduction in their feed intake compared with hens fed the basal diet alone or with 5% ME. But, during the 10th period feed intake was significantly reduced in hens fed the basal diet compared to those fed diets supplemented with 10 or 15% ME. Yet, the overall average daily feed intake was not affected by any of the dietary treatments. Increasing dietary ME value by 5 or 15% significantly increased egg production compared to the control diet during the 11th period only, but in general, the average hen-day production was numerically improved by the addition of dietary energy to the basal diet. Egg weight was significantly reduced at the 3rd, 4th, and 7th periods by increasing dietary energy by 10% ME.

The results of dietary energy on hen-day egg mass production, feed conversion, Haugh unit scores, and egg shell thickness are shown in Table 4. No significant effects on periodic hen-day egg mass production were observed during periods 1 through 9, but during periods 10 and 11, mass production was numerically improved and significantly increased, respectively, by increasing dietary ME by either 5 or 15%. A 5% ME increase of dietary energy significantly reduced feed conversion in the 2nd period. In periods 3, 4, 5, and 6, numerical reductions in feed conversion due to the additional 5% ME of dietary energy were observed. However, these effects were not statistically significant until the 11th period. The addition of 5 and 15% ME dietary energy to the diets significantly reduced Haugh unit scores in the 1st period. The additional dietary corn oil significantly improved egg shell thickness during the 5th period. Also, in the 10th period, hens fed diets supplemented with 5 and 15% ME showed a significant increase in egg shell thickness compared with hens fed the basal diet

Table 3. Effect of dietary treatments on average body weight, feed intake, egg production, and egg weight of White Leghorn hens[1]

Variable	Dietary treatments	Period[2] 1	2	3	4	5	6	7	8	9	10	11	Average
Body weight,	Basal (control)	1.81	1.69	1.73	1.82	1.88	1.90	1.82	1.92	1.93	1.94	1.89	1.85
Kg	Basal + 5% ME	1.82	1.73	1.71	1.80	1.85	1.88	1.80	1.84	1.87	1.87	1.87	1.82
	Basal + 10% ME	1.84	1.68	1.74	1.77	1.82	1.82	1.77	1.85	1.93	1.92	1.88	1.82
	Basal + 15% ME	1.88	1.71	1.74	1.78	1.84	1.85	1.82	1.77	1.89	1.92	1.90	1.83
	Pooled SEM	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.06	0.06	0.04	0.05	0.04
Feed intake,	Basal (control)	114.7	102.9^{a}	104.8^{a}	106.7	108.8	107.3	99.3	111.3	114.5	114.9^{b}	117.0	109.3
g/hen/day	Basal + 5% ME	115.5	98.2^{b}	104.2^{a}	106.9	109.9	107.9	99.9	112.0	116.3	118.2^{ab}	117.4	109.7
	Basal + 10% ME	113.7	102.2^{a}	102.0^{b}	106.7	108.7	107.4	103.8	113.2	119.2	122.3^{a}	118.7	110.7
	Basal + 15% ME	115.6	101.1^{a}	101.0^{b}	106.7	109.4	107.2	102.9	114.2	120.7	125.2^{a}	123.1	111.4
	Pooled SEM	0.7	0.6	0.5	2.5	1.1	0.9	1.7	1.3	1.7	2.3	2.4	0.8
Hen-day egg	Basal (control)	86.8	92.4	89.3	90.1	88.2	86.6	84.1	84.9	85.1	78.5	67.5^{c}	84.6
production, %	Basal + 5% ME	83.9	92.5	90.5	92.2	91.5	89.8	83.2	84.9	83.5	82.1	79.5^{ab}	86.8
	Basal + 10% ME	87.0	91.4	87.2	90.4	88.9	87.1	84.7	85.3	87.9	81.5	74.0^{bc}	85.9
	Basal + 15% ME	85.5	91.2	87.9	87.6	85.7	89.7	81.3	80.7	85.2	88.0	83.0^{a}	86.0
	Pooled SEM	2.2	1.3	1.4	2.0	2.0	1.5	2.4	2.6	2.3	3.3	2.8	1.4
Egg weight, g	Basal (control)	56.1	57.0	58.2^{a}	59.1^{a}	60.1	61.5	61.7^{a}	62.1	63.8	64.4	64.0	59.5
	Basal + 5% ME	56.3	58.0	58.1^{a}	58.2^{a}	59.3	60.8	59.1^{b}	60.6	63.1	64.0	64.0	60.2
	Basal + 10% ME	54.9	55.9	56.1^{b}	58.2^{b}	57.0	59.0	58.5^{b}	60.1	62.9	63.7	64.2	59.0
	Basal + 15% ME	55.6	56.7	57.6^{a}	57.5^{ab}	59.0	60.0	59.2^{b}	61.1	63.4	65.1	65.0	60.0
	Pooled SEM	0.5	0.8	0.5	0.6	0.8	0.6	0.6	0.7	0.6	0.7	0.7	0.7

^{a,b} Means within a column with no common superscript are significantly different ($P<.05$)

[1] Each diet was fed to five replicate groups of 8 hens for 44 weeks

[2] Period = 28 days

Table 4. Effect of dietary treatments on average hen-day mass production, feed conversion, Haugh unit scores, and egg shell thickness of White Leghorn hens[1]

Variable	Dietary treatments	Period[2] 1	2	3	4	5	6	7	8	9	10	11	Average
Hen-day egg mass	Basal (control)	48.7	52.6	52.0	53.2	53.1	53.2	51.9	52.8	54.3	50.5	43.3[c]	51.4
production, g/hen	Basal + 5% ME	47.3	53.7	52.5	53.8	54.2	54.6	49.2	51.4	52.7	50.7	50.8[ab]	51.9
	Basal + 10% ME	47.8	51.1	49.1	50.8	50.7	51.3	49.5	51.1	55.3	51.8	47.4[bc]	50.5
	Basal + 15% ME	47.6	51.8	50.6	50.5	50.6	53.8	48.1	49.3	54.3	57.2	53.0[a]	51.6
	Pooled SEM	1.3	0.9	1.1	1.5	1.3	1.0	1.6	1.5	1.6	1.8	1.9	0.9
Feed conversion, g/g	Basal (control)	2.36	1.95[a]	2.02	2.01	2.05	2.02	1.92	2.12	2.12	2.28	2.73[a]	2.14
egg mass production	Basal + 5% ME	2.45	1.83[b]	1.98	1.99	2.02	1.98	2.05	2.18	2.22	2.34	2.32[c]	2.12
	Basal + 10% ME	2.38	2.00[a]	2.09	2.10	2.15	2.09	2.10	2.22	2.16	2.39	2.52[ab]	2.20
	Basal + 15% ME	2.44	1.96[a]	2.00	2.10	2.17	2.03	2.17	2.34	2.24	2.19	2.28[b]	2.17
	Pooled SEM	0.06	0.03	0.04	0.05	0.06	0.04	0.09	0.07	0.08	0.07	0.09	0.04
Haugh unit scores	Basal (control)	85.9[a]	82.4	88.2	68.7	88.9	86.9	91.3	89.7	85.7	86.2	79.3	84.4
	Basal + 5% ME	81.6[c]	82.5	85.6	67.4	82.7	86.7	89.1	86.9	84.6	81.1	81.2	82.7
	Basal + 10% ME	84.4[ab]	83.4	85.2	65.7	85.7	83.5	85.8	84.3	86.0	80.5	77.6	82.0
	Basal + 15% ME	81.9[bc]	82.0	85.3	69.0	84.1	83.3	87.6	88.8	81.0	80.4	75.0	81.7
	Pooled SEM	0.8	0.9	1.3	1.8	2.1	2.4	1.8	1.9	1.9	2.5	2.0	0.8
Egg shell thickness,	Basal (control)	0.410	0.394	0.384	0.406	0.394[b]	0.392	0.398	0.394	0.380	0.365[b]	0.395	0.391
mm	Basal + 5% ME	0.418	0.394	0.390	0.396	0.400[ab]	0.398	0.396	0.388	0.392	0.390[a]	0.402	0.393
	Basal + 10% ME	0.412	0.396	0.378	0.400	0.392[b]	0.392	0.396	0.392	0.383	0.375[ab]	0.399	0.392
	Basal + 15% ME	0.414	0.394	0.388	0.402	0.408[a]	0.396	0.402	0.394	0.395	0.386[a]	0.402	0.393
	Pooled SEM	0.005	0.003	0.004	0.003	0.003	0.003	0.006	0.004	0.004	0.005	0.004	0.002

[a-c] Means within a column with no common superscript are significantly different (P< 05)
[1] Each diet was fed to five replicate groups of 8 hens for 44 weeks
[2] Period = 28 days

alone.

DICUSSION

The negative effects of high environmental temperature on the performance of chickens have been reported by numerous researchers. In laying hen studies, it was reported that as the ambient temperature increases, feed intake decreases (Njoku and Nwazota, 1989; North and Bell, 1990; Paguri and Coon, (1993), and consequently egg production decreases (Miller and Sunde, 1975; Engster and Snetsinger, 1980), egg weight is reduced (De Andrade et al., 1976) and the efficiency of feed utilization is depressed (Njoku and Nwazota, 1989). However, earlier literature indicated that many of these studies which incorporated heat stress as factor, had been conducted under constant high temperature (Diab et al., 1987; Dale and Fuller, 1980; Miller and Sunde, 1975). Also, it was reported that the performace of laying hens (Miller and Sunde, 1975) differed when experiments were conducted under constant high temperature vs. cycling temperature.

Njoku and Nwazota (1989) reported that feed intake and the efficiency of feed utilization were increased with the use of dietary oil fed to laying hens raised in a hot tropical environment. In this present study, hens fed a basal diet + 5% ME showed a significant reduction in feed intake in the 2nd period compared with hens fed the control diet under the cycling high temperature condition (Table 3). In each treatment these birds almost consumed the same amount of feed for the rest of the trial. However, there was a signigficant reduction or improvement in the feed conversion ratio of hens fed the basal diet + 5% ME (supplied by corn oil) compared with hens fed the control diet in the 2nd period, and this improvement was continuously observed in the 3rd through 6th periods, but was not statistically significant until the 11th period. This may be due to the beneficial effect of using dietary fat with reduced heat increament under this condition. Similar observations were obtained with hen-day egg production and hen-day egg mass production data. However, these improvements were not statistically significant until the 11th period. Cunningham and Morrison (1977) observed that the efficiency of feed utilization was improved with the use of dietary oil in laying hen diets. This may be attributable to the lower energy cost of dietary fat metabolism, and consequently, the assimilation and the synthesis of the dietary fat into the egg yolk during the egg formation process. In a laying hen study, Li et al. (1992) investigated the relationship between environmental temperature, heat production, and feed intake. They found the metabolic heat production associated with feed intake was dependant on both environmental temperature and intake, and could be an additional heat load at higher environmental emperatures. A study conducted by Carew and Hill (1964) on the effect of corn oil on metablic efficiency of energy utilization in broilers reported that corn oil decreased the heat increment of the diet. Gill and Gangwar (1984) indicated that feed intake was the same for hens raised in airconditioned temperature (28 to 30^{0}C) and hens raised in natural summer conditions (28 to 38^{0}C) in India. Njoku and Nwazota (1989) observed similar results with egg production and egg weight when 50 g palm oil/kg was used in the laying hens diet. Diambra et al. (1993) reported that hens receiving the high-calorie (in the form of supplemental fat), low-protein diet performed the best among all treatments under hot tropical conditions. Also, De Andrade et al. (1976) reported that egg weight was increased due to the addition of dietary oil rather than the addition of protein to the diet.

The increase of dietary energy to 10% ME in the basal diet significantly reduced feed intake during the 3rd period. As a result of reduced feed intake, and thus, of the essential nutrients, egg production was reduced for hens fed diets containing 10 or 15% ME compared with hens fed the control diet. But, this reduction was not statistically significant. Also, egg weight was significantly reduced for hens fed the basal diet + 10% ME in the 3rd period. In contrast, during the 10th through the 11th periods, feed intake was increased in hens fed the basal diets + 10 and 15% ME compared to those fed the basal diet alone. This increment in feed intake of hens fed the basal diet +15 % ME was accompanied by a numerical improvement in egg production, egg weight, hen-day egg mass production, and a significant improvement in egg shell thickness during the 10th period. In addition, the improvements in egg production, feed conversion, and hen-day egg mass production were statistically significant at the 11th period.

The inclusion of 50 g palm oil/kg in a laying hen diet was studied by Njoku and Nwazota (1989). They found that palm oil reduced the negative effect of heat stress and improved egg production, egg weight, feed intake, and efficiency of feed utilization. In this present study, a 5% ME (16 g corn oil/kg diet) increase in corn-soybean meal layer diets significantly reduced feed intake and improved feed conversion in the 2nd period under cycling high temperature condition, and numerically improved egg production compared with hens fed the control diet. Also, a similar trend was found regarding egg production, hen-day egg mass production, and feed conversion during the 11th period only.

Gill and Gangwar (1984) found that heat stress significantly reduced egg shell thickness and Haugh unit scores of layhing hens raised in hot climates. Engster and Snetsinger (1980) found similar resuts regarding shell thickness. On the other hand, Njoku and Nwazota (1989) reported that the addition of palm oil to the diet did not improve shell thickness and Haugh unit scores in a hot tropical environment. In this present study, Haugh unit scores data (Table 4) indicated that there was little effect of dietary treatments on this parameter. The addition of corn oil to provide an increase of dietary energy by 15% significantly increased egg shell thickness in the 5th and 10th periods only, but the overall average was just slightly improved compared with the control.

In conclusion, the results of this study showed that increasing ME (in the form of corn oil) in laying hen diets had little or no significant effect on any of the parameters studied. The only exception was the basal diet + 5% ME, which showed t emporary periodic improvements in the efficiency of feed utilization, egg production, and hen-day egg mass production under a hot cyclic climatic condition. This may be attributed to a reduction in heat increment as a result of using dietary fat under these climatic conditions.

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تأثير المستويات العاليه من طاقة الغذاء علي آداء الدجاج البياض تحت ظروف المناخ الحار

احمد سليمان حسين

قسم الأنتاج الحيوانى ، كلية العلوم الزراعية ، جامعة الامارات العربية المتحدة . ص.ب: ١٧٥٥٥ العين - الامارات العربية المتحدة

ملخص :

تم دراسة تأثير رفع طاقة الغذاء (باستخدام زيت الذرة) على كفاءة الدجاج البياض من سلالة " Bovan WL " ، تحت ظروف الحرارة العالية . استخدمت خمس مجموعات (المجموعة مكونه من ثمان دجاجات) عمر ٢٥ اسبوع ، كل اثنتان فى قفص واحد ، وقد تم توزيعها عشوائياً لكل معاملة من المعاملات التجريبيه الاربع . كان متوسط درجات الحرارة المسجلة يومياً ٢٦ ° م في الساعة السابعه صباحاً و ٣٢ ° م فى الواحده بعد الظهر ، تكونت عليقه الدجاج البياض الاساسيه من مسحوق الذرة وكسب فول الصويا وكانت تحتوي علي ١٧.٥٪ بروتين خام ، ٢.٨ ميجا كالوري طاقه تمثيلية لكل كيلو جرام عليقه وأيضاً تحتوى علي نسبه ٣.٥٪ كالسيوم وعلي نسبه ٠.٥٪ فوسفور متاح . المعاملات التجريبيه كانت مكونه من التغذية حتي الشبع لكل من : (١) العليقه الاساسيه بمفردها (عليقه مقارنة) أو مع زيادة تدريجية في محتوي الطاقة بواسطه استخدام زيت الذره للوصول الي زيادة فى مستوي الطاقه التمثيليه للعليقه الي (٢)

٥٪ أو (٣) ١٠٪ أو (٤) ١٥٪. سجلت قياسات كميه الغذء المأكول ، وزن الدجاج ، كمية البيض ووزنه وقياس مواصفاته الداخليه (Haugh Unit) وسمك القشرة كل ٢٨ يوماً . واستمرت التجربه لمدة ٤٤ اسبوعاً (١١ دورة تجريبية مدة كل منها ٤ أسابيع) وجد أن الدجاج البياض المغذى على عليقه بها زيت ذرة انخفضت كميه العليقه المأكولة معنوياً (احتمال ٥٪) بالمقارنه بالدجاج المغذى علي عليقة المقارنه فقط في نهايه الدورة الثانيه والثالثه . وأدي رفع مستوى الطاقه التمثيليه بنسبه ٥٪ في عليقه الدجاج البياض الي زيادة غير معنويه فى انتاج البيض ومعامل التحويل الغذائى خلال سير التجربه ، كما أدي الي زيادة معنويه فى انتاج البيض كماً ووزناً وتحسين معنوى في نسبة التحويل الغذائى خلال الدورة الحادية عشرة . انخفض وزن البيض في الدورات الثالثه والرابعه والسابعه عند رفع مستوى الطاقه ١٠٪ ولوحظ أن اضافة زيت الذرة في عليقه الدجاج البيض أدت الي زيادة معنوية فى قشرة البيضه خلال الدورة الخامسه والعاشرة من التجربه .

كلمات مفتاحية : مناخ ، انتاج البيض ، طاقه ، الدجاج البياض ، الحرارة