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Effects of Dietary Energy and Vitamin C on Growth Performance of Broiler Chicks Raised in Hot Climates

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ABSTRACT

Two experiments were conducted to determine the effect of dietary energy and vitamin C interaction on growth performance using broiler chicks of a commercial strain raised under hot climates. Experiment 1, a 28-day trial, examined the effects of providing high levels of dietary energy in the form of corn oil on growth performance of broilers. Four dietary treatments consisted of feeding the basal diet alone or with graded levels of corn oil to provide increases of 5, 10, and 15% ME. A 15% increase of ME significantly improved body weight and gain/feed ratio of broiler chicks. Experiment 2, a 49-day trial, examined the interactive effects of dietary energy and vitamin C on growth performance. Dietary treatments provided two levels of energy (basal or added 15% ME) and two levels of vitamin C (0 or 200 mg/kg) in a complete factorial design. The addition of dietary energy to the basal diet significantly improved gain/feed ratio, while vitamin C alone insignificantly improved gain/feed ratio. The results indicated that dietary corn oil could alleviate some negative effects of heat stress.

Key Words: Energy, vitamin C, broilers, hot climates, corn oil.

INTRODUCTION

High environmental temperatures have been shown to cause considerable economic loss to the poultry industry in several regions of the world. Heat stress has been shown to have negative effects on growth performance of broiler chicks (Deaton et al., 1973 and Dale and Fuller, 1980) and on laying hen performance (Miller and Sunde, 1975; De Andrade et al., 1976; and Njoku and Nwazota, 1989). A considerable amount of research has been conducted in this area in an attempt to overcome the negative effect of heat stress on poultry production. Some researchers utilized dietary fat (Dale and Fuller, 1980 and Njoku and Nwazota, 1989); others used vitamin C (Njoku and Nwazota, 1989; Pardue and Thaxton, 1986; and Stillborn et al., 1988); and other researchers investigated the alteration of dietary protein and amino acids (Yanming and Baker, 1993). However, most modern studies were done with constant high temperatures; very little has been done to study the effects of natural cyclic temperatures on broilers (Dale and Fuller, 1980 and Stillborn et al., 1988).

There are numerous, inconsistent and controversial reports surrounding the importance of the role of vitamin C in poultry nutrition, especially regarding poultry performance under heat stress. Some researchers showed that vitamin C has a positive effect on broilers subjected to high temperatures (Pardue et al., 1983), while others reported that vitamin C had little or no beneficial effect on broilers (Stillborn et al., 1988). Furthermore, most of these studies dealt with hot constant rather than cyclic temperatures. Although the poultry industry in the United Arab Emirates has rapidly developed over the last two decades, the author is unaware of any research conducted regarding broiler performance under heat stress in the Emirates. The objectives of the present study were to determine the effect of feeding graded levels of dietary energy, and the interactive effect of dietary energy and vitamin C, on growth performance of broiler chicks raised in hot climates.

MATERIALS AND METHODS

Experiment 1: The objective of the first experiment was to examine the effects of providing high levels of dietary energy in the form of corn oil on the growth performance and carcass yield of broiler chicks raised in natural hot cycling temperatures. Commercial Hybro broiler chicks, 21 days of age, were brooded on floor pens (250 cm long x 250 cm wide) under normal conditions in a closed house system. Three replicate groups of 36 straight run chicks were randomly assigned to each of four dietary treatments. The chicks were housed in floor pens for 28 days, and feed and water were provided *ad libitum*. The dietary treatments consisted of feeding the basal diet (broiler grower-finisher containing 21% crude protein and 3050 Kcal ME/Kg) alone (Table 1) or with graded levels of corn oil, 1.7, 3.4 and 5.1%, to provide increases of 5, 10, and 15% ME, respectively. The calculated nutrient composition of the diets, based on ingredient composition tables (Scott et al., 1982), is shown in Table 1. The basal diet is with zero corn oil added, diets 2, 3 and 4 are with graded levels of dietary corn oil added. Table 2 shows that adding corn oil to the basal diet increased ME values to 3.2, 3.36 and 3.5 Mcal/kg. At the same time the other main nutrients such as protein, amino acids, calcium and phosphorus were diluted, yet their amount in the diet was still above the NRC (1994) requirements for these nutrients. In addition, the calorie-to-protein ratio increased in the diets containing corn oil compared to the basal diet. Body weight and feed intake were measured weekly. At the end of the trial, all birds were sacrificed by severing the jugular vein, processed, and the average group weight taken to obtain the carcass yield data. Air temperature and relative humidity of the broiler house were recorded daily at 7:00 a.m. and 1:00 p.m., and the means calculated on a weekly basis (Table 3).

Experiment 2: The objective of the second experiment was to determine the interactive effects of dietary energy and vitamin C on growth performance of broiler chicks raised under hot climates. Three replicate groups of 37 commercial broiler chicks (straight runs) were assigned for each treatment. The chicks, 1-day old, were housed and managed the same as in experiment 1. Dietary treatments consisted of feeding broiler chicks *ad libitum*, a basal starter diet containing 23% crude protein and 3000 Kcal ME/Kg (from day 1 to day 21) and basal grower-finisher diets (from day 22 to day 49). Dietary treatments consisted of providing two levels of energy (basal or added 15% ME) added as corn oil to the basal diets (Table 1) and two levels of vitamin C (0 or 200 mg/kg, coated ascorbic acid; Hoffman-LaRoche, Inc., Basel, Switzerland) in a complete factorial design. Diets were freshly mixed on a weekly basis. Feed intake and body weight were measured weekly as well. Natural daily temperature and relative humidity were managed and calculated the same as in experiment 1. The experiment was designed to expose the birds to high environmental temperatures during the hot summer months (July-September) of 1994.

Statistical Analysis: The collected data were subjected to analysis of variance (ANOVA) testing for the effect of the level of dietary corn oil as well as for linear, quadratic and cubic effects (Snedecore and Cochran, 1980) in experiment 1 or to ANOVA based on complete factorial design (Experiment 2) using the general linear model (GLM) program (SAS, 1982). The test of least significant difference was used to separate means only when a significant F value was obtained in the analysis of variance table (Snedecore and Cochran, 1980). A probability of $<.05$ was used for all statistical analyses.

RESULTS AND DISCUSSION

The effect of dietary treatments on body weight, feed intake, body weight gain, and the efficiency of feed utilization (gain/feed ratio) of broiler chicks in experiment 1 is shown in Table 4. Dietary corn oil, added to provide an increase of 15% ME to the basal diet, significantly ($P<.05$) increased the weekly body weight of chicks fed this, as opposed to the basal, diet at weeks 5, 6, and 7. Also, the effect of increasing dietary energy in the form of added corn oil on body weight resulted in a significant ($P<.05$) linear effect of corn oil at 5, 6 and 7 weeks of age. A 5% or 10% ME increase of the basal diet's value significantly reduced the total feed intake of chicks fed those diets compared to those fed the basal diet alone. At the end of the fifth week, significaquadratic and cubic effects were observed on feed intake due to adding corn oil to the basal diet; at the same time body weight gain of chicks fed the basal diet was significantly reduced by approximately 18% and 24%, compared to those birds fed basal diets containing increased dietary energy by 10% and 15% ME, respectively. Also, the effect of increasing dietary energy in the form of added corn oil on body weight gain resulted in a significant linear and quadratic effects at the fifth and the final weight gain, respectively (Table 4). Total gain/feed ratio of chicks fed a basal diet plus 15% of its ME value showed a significant improvement compared to those chicks fed the other treatments. In addition, added corn oil in the basal diet resulted in a significant linear ($P<.01$) effect on the total gain/feed ratio of broiler chicks. The results of carcass yield data showed that there was no treatment effect on this parameter (Table 4).

The effects of feeding combinations of two levels of energy and two levels of vitamin C to broiler chicks (experiment 2) for seven weeks on body weight, feed intake, body weight gain, and gain/feed ratio are shown in Table 5. Body weight was significantly ($P<.05$) increased by increasing dietary corn oil (main effect, $P<.05$) the second week. The final body weight was improved by the addition of dietary energy, vitamin C, or both, but this improvement was not statistically significant compared to the control. No difference among treatments was observed regarding feed intake. However, total feed intake was numerically reduced by increasing dietary energy, and/or adding vitamin C to the basal diet, but these results were not significantly different. Similar observations were obtained with total body weight gain as well as final body weight; chicks that received diets containing high energy levels, vitamin C, or both, gained more weight than those which received the basal diet only, but these improvements were not statistically significant. Dietary energy in the form of corn oil improved the efficiency of feed utilization (gain/feed ratio) at the fourth week of the trial, and there was a ME x vitamin C interaction observed on gain/feed ratio. At the fifth week of age there was a significant main effect observed of dietary corn oil and vitamin C on gain/feed ratio. Corn oil, added to provide an increase of 15% ME to the basal diet, significantly improved the efficiency of feed utilization (gain/feed ratio) of broiler chicks.

It's been known for years that vitamin C can be synthesized by chickens, and thus, is not required to be added to poultry rations. However, the inclusion of vitamin C in the diet has beneficial effects on the performance of poultry exposed to heat stress (Pardue and Thaxton, 1986). Orban et al. (1993), indicated that under normal environmental temperatures, the addition of vitamin C (up to 3000 ppm) to the diet of broiler chicks had little effect on body weight gain and feed efficiency.

They explained these findings on the basis that chickens produce ascorbic acid in their body, and if there is no stress factor involved, their requirements will be met and the addition of vitamin C in the diet will not produce any significant effect. In experiment 2 (Table 5) there was no significant improvement from the addition of vitamin C (200 ppm) to broiler diets on body weight gain or gain/feed ratio. Stillborn, et al., (1988) reported that the addition of ascorbic acid to the broiler diet had no beneficial effects on broiler growth or feed efficiency under heat stress. Pardue et al., (1985a) reported similar findings in which vitamin C was added to the broiler diet following exposure of chicks to high environmental temperatures. In addition, the present study (Table 5) does not agree with the findings of Njoku (1986), who reported that the addition of 200 mg/kg vitamin C to the broiler diet increased body weight gain in a hot tropical climate.

The results of increasing dietary energy by 15% of the ME value by adding corn oil to the basal diet showed a positive effect on the efficiency of feed utilization (gain/feed ratio) of broiler chicks in trial 1 (Table 4) as well as in trial 2 (Table 5). It was found in both trials that under hot natural summer temperatures, feed intake was reduced in broiler chicks fed the basal diet + 15% ME, compared to those chicks fed the basal diet alone (Tables 4 and 5). In a broiler study conducted during a hot summer in Georgia (U.S.), it was recorded that high temperatures ranged from 30 to 37.2^{0}C and the low from 16.1 to 25.6^{0}C. It was found that birds receiving the high-fat diet consumed more feed per bird and significantly gained more weight than those fed only the high-carbohydrate diet (Dale and Fuller, 1978). Also, the same authors in 1979, reported that broiler chicks fed a diet containing high levels of fat significantly improved in body weight gain compared to chicks fed a high-carbohydrate diet. These researchers also found that replacing carbohydrate with fat calories did not reduce feed intake as was expected in hot temperatures. A similar observation was obtained in the present study regarding feed intake. Furthermore, Dale and Fuller (1980), reported that under cycling conditions (14 to 22^{0}C or 22 to 33^{0}C), as would occur under normal conditions, the negative effect due to heat stress was less in chicks fed the diets high in fat. Their explanation of this phenomenon, that of the special benefit of dietary fat in hot climates, was probably the result of reduced heat increment. Njoku and Nwazota (1989), reported that the use of 50g palm oil/kg diet reduced the effect of heat stress and increased laying hen performance in a hot tropical environment. They explained this positive response on the basis that since dietary fat has a low-heat increment (Dale and Fuller, 1980), fat supplementation alone has the potential to alleviate some of the negative effects of high ambient temperatures. Also, Carew and Hill (1964), reported that the inclusion of dietary corn oil in the broiler diet tends to decrease the heat increment. It was additionally reported that under high ambient temperatures, the rate of passage of the feed decreased, which can lead to better enzyme digestion and feed utilization (Wilson et al.,1980). The above argument may explain the positive responses of the addition of corn oil to the diet in experiments 1 and 2 (Tables 4 and 5) on the gain/feed ratio. Istaytiyyah (1987) found, on the other hand, that the addition of 5% corn oil to a conventional broiler diet failed to overcome the negative effect of constant heat stress (32^{0}C). He reported that the constant high temperature significantly reduced the growth performance of broiler chicks compared to cyclic (17 to 30^{0}C) temperature during the growth period of 28 to 49 days. However, Diab et al.,1987, found that when broiler chicks raised under high constant heat stress (36^{0}C) were fed diets containing 4.5% oil, their body weight gain and feed efficiency were improved compared to those chicks fed the low-energy diet.

It is known that the reduction of plasma corticosterone tends to improve the growth performance of birds. Schmeling and Nockels (1978), reported that vitamin C reduced plasma corticosterone in poultry. Also, Pardue et al. (1985b), reported that vitamin C supplementation of broiler diets significantly reduced plasma corticosteroid levels in heat stressed birds. Pardue and Thaxton (1986), further reported that dietary vitamin C has some beneficial effects on poultry performance especially under heat stress. However, these arguments are not supported in the findings of the present study; the addition of vitamin C to the basal diet had no significant effect on body weight gain or gain/feed ratio (experiment 2) (Table 5). These findings are similar to those reported by Stillborn et al., 1988, who found that vitamin C had no beneficial effect on weight gain or feed efficiency of broiler chicks maintained under heat stress.

In summary, adding dietary corn oil improved gain/feed ratio of broiler chicks raised in hot climates. The use of corn oil in diet may help alleviate some of the negative effects of heat stress on broilers. The addition of vitamin C had no significant effect on weight gain or gain/feed ratio of chicks maintained in hot climates.

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Table 1. Composition of basal diets.

Ingredient	Starter	Grower-Finisher
	%	
Ground yellow corn	63.25	68.20
Dehulled soybean meal (48% CP)	26.60	23.35
Meat and bone meal	5.30	2.75
Menhaden fish meal	3.20	3.90
Salt	0.35	0.35
Ground limestone	0.40	0.60
Dicalcium phosphate (22% Ca, 18.5% P)	0.60	0.55
Vitamin-mineral premix[A]	0.10	0.10
DL-Methionine (99%)	0.20	0.20
Calculated nutrient composition		
ME, Mcal/kg	3.00	3.05
Protein, %	23.00	21.00
Calcium, %	1.11	0.94
Phosphorus, available, %	0.60	0.46
Lysine, %	1.26	1.14
Methionine, %	0.59	0.57
Methionine + cystine, %	0.96	0.92

[A] Provided the following per kilogram of diet: vitamin A, 6,000 IU; vitamin E, 15 IU; menadione dimethylpyrimidinol bisulfite, 4.4 mg; thiamin, 2.7 mg; riboflavin, 5.4 mg; panthothenic acid, 15 mg; niacin, 41 mg; pyridoxine, 4.5 mg; biotin, .23 mg; choline, 1,450 mg; folacin, .83 mg; vitamin B_{12}, .014 mg; ethoxyquin, 125 mg; selenium, .2 mg; copper, 6 mg; iodine, .53 mg; iron, 120 mg; manganese, 83 mg; zinc, 69 mg; and cobalt, 5 mg.

Table 2. Nutrient composition of deitary treatments

Treatments	1	2	3	4
% Corn oil added to the basal diet	0	1.7	3.4	5.1
ME, Mcal/kg	3.05	3.2	3.36	3.5
Protein %	21	20.6	20.3	20
Calcium %	0.94	0.92	0.91	0.90
Phosphorus av.%	0.46	0.45	0.44	0.43
Lysine %	1.14	1.12	1.1	1.09
Methionine %	0.57	0.56	0.55	0.54
Met + Cys %	0.92	0.90	0.89	0.88
Calorie: Protein	145	155	165	175

Table 3. Average air temperature and relative humidity inside broiler house

Trial	Month	Week	Temperature, °C 7:00 a.m.	R.H.[A] 7:00 a.m.	Temperature, °C 1:00 p.m.	R.H.[A] 1:00 p.m.
1	May	4	27	45	30	41
	May	5	28	57	32	53
	June	6	24	64	32	69
	June	7	24	55	35	52
2	July	1	33	63	34	68
	July	2	31	68	33	56
	Aug	3	31	57	34	49
	Aug	4	29	68	33	51
	Aug	5	29	56	33	47
	Aug	6	28	72	33	50
	Sept	7	28	71	32	49

[A] R.H. = Relative humidity

Table 4. Experiment 1: Effect of increased dietary energy in the forms of corn oil on growth performance and carcass yield of broiler chicks[1]

	Percentage of ME increased				Pooled
Variable	0	5	10	15	SEM
Body weight, g					
Week 4	971	969	934	980	27
Week 5[3]	1439^{b}	1446^{b}	1487^{ab}	1559^{a}	21
Week 6[3]	1913^{b}	1906^{b}	1937^{b}	2038^{a}	24
Week 7[3]	2283^{b}	2241^{b}	2285^{b}	2423^{a}	31
Feed intake, g					
Week 4	840^{a}	791^{b}	821^{a}	819^{ab}	8
Week 5[4]	894^{a}	842^{b}	875^{a}	875^{a}	8
Week 6	1041	1006	1003	1015	15
Week 7	1064	1045	1036	1045	14
Total	3838^{a}	3684^{b}	3736^{b}	3754^{ab}	26
Body weight gain, g					
Week 4	336	364	286	335	23
Week 5[3]	468c	477^{bc}	553^{ab}	579^{a}	24
Week 6	474	461	449	479	13
Week 7	370	335	349	385	35
Total[5]	1678^{ab}	1637^{b}	1637^{b}	1778^{a}	29
Gain/Feed					
Week 4	0.436	0.459	0.347	0.407	0.027
Week 5[3]	0.518	0.567	0.632	0.663	0.032
Week 6	0.456	0.458	0.448	0.471	0.007
Week 7	0.348	0.320	0.336	0.369	0.034
Total[6]	0.437^{b}	0.444^{b}	0.438^{b}	0.474^{a}	0.007
Eviscerated weight, g[2]	1680	1664	1690	1810	39
Carcass yield, %	74	74	74	75	2

$^{a-c}$ Means within a row with no common superscript are significantly different ($P<.05$)

[1] Added as corn oil to the basal diet; each diet fed to three replicate groups of 36 chicks for 28 days

[2] Eviscerated carcass weight with the chicken neck

[3] Significant linear effect ($P<.05$)

[4] Significant quadratic and cubic effects ($P<.05$)

[5] Significant quadratic effect ($P<.05$)

[6] Significant linear effect ($P<.01$)

Table 5. Experiment 2: Effects of dietary energy and Vitamin C on growth performance of broiler chicks[1]

Variable	Dietary treatments		Week							
	ME, %	Vitamin C, mg/Kg	1	2	3	4	5	6	7	Total
Body weight, g	0	0	118	330	633	1032	1447	1828	2099	
	15	0	122	341	633	1031	1445	1826	2151	
	0	200	120	330	612	1021	1426	1793	2148	
	15	200	120	339	640	1045	1485	1901	2233	
Pooled SEM			1	3	7	15	24	28	46	
Significant Effects				ME						
Feed intake, g	0	0	105	294	512	752	934	1023	1056	4676
	15	0	110	302	503	676	868	984	1000	4443
	0	200	108	313	497	710	861	1021	1076	4585
	15	200	109	314	548	719	855	1002	1039	4587
Pooled SEM			2	12	31	21	19	24	34	125
Body weight gain, g	0	0	76	212	303	399	415	381	271	2057
	15	0	80	219	292	398	414	381	325	2109
	0	200	78	210	282	408	406	367	355	2107
	15	200	78	219	301	405	440	416	333	2171
Pooled SEM			1	3	7	11	10	15	36	45
Gain/Feed	0	0	0.728	0.723	0.592	0.531^{b}	0.445	0.373	0.257	0.440
	15	0	0.732	0.727	0.584	0.589^{a}	0.478	0.387	0.326	0.475
	0	200	0.723	0.672	0.571	0.575^{ab}	0.471	0.361	0.329	0.460
	15	200	0.719	0.699	0.552	0.565^{ab}	0.515	0.414	0.317	0.474
Pooled SEM			0.018	0.031	0.024	0.015	0.007	0.017	0.029	0.005
Significant Effects						ME x Vitamin C	ME and Vitamin C			ME

[1] Each diet was fed to three replicate groups of 37 chicks for seven weeks.
** Means within a column with no common superscript are significantly different (P<.05).

مجلة الإمارات للعلوم الزراعية (١٩٩٦) ٨ : ٤٩-٦٢

تأثير الطاقة الحرارية وفيتامين ج على أداء دجاج اللحم تحت ظروف الحرارة العالية.

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قسم الإنتاج الحيواني ، كلية العلوم الزراعية ، جامعة الإمارات العربية المتحدة ص.ب. ١٧٥٥٥ العين - الإمارات العربية المتحدة

ملخص :

استخدمت تجربتان لدراسة تأثير استخدام الطاقة الحرارية وفيتامين ج ومعامل التفاعل بينهما على كفاءة نمو دجاج اللحم التجاري تحت ظروف الحرارة العالية . في التجربة الأولى كانت مدة التجربة ٢٨ يوما لدراسة تأثير رفع الطاقة الحرارية للعليقة بواسطة استخدام زيت الذرة على كفاءة نمو دجاج اللحم استخدمت أربعة معاملات مكونة من تغذية العليقة الأساسية بمفردها (عليقة مقارنة) أو مع زيادة تدريجية في محتوى الطاقة التمثيلية للعليقة بمقدار ٥٪ أو ١٠٪ أو ١٥٪ وجد أن الدجاج المغذي على عليقة بها زيادة ١٥٪ في الطاقة التمثيلية تحسنت وزنه وكفاءة معامل التحويل الغذائي له . استمرت التجربة الثانية لمدة ٤٩ يوما لدراسة معامل التفاعل بين استخدام كل من الطاقة الحرارية وفيتامين ج على كفاءة نمو دجاج اللحم. وكانت المعاملات التجريبية مكونة من استخدام مستويان من الطاقة الحرارية (عليقة مقارنة أو مضاف إليها ١٥٪ زيادة في الطاقة الحرارية) ومستويان من فيتامين ج (صفر و٢٠٠ مليجرام/كيلوجرام عليقة)، وجد أن إضافة الطاقة التمثيلية إلى العليقة الأساسية أدى إلى زيادة معنوية في معامل التحويل الغذائي للدجاج ، بينما أدت اضافة فيتامين ج إلى زيادة غير معنوية في معامل التحويل الغذائي. وتوضح هذه النتائج أن استخدام زيت الذرة قد يؤدي إلى تخفيف التأثير السلبي للحرارة العالية على الدجاج.

كلمات مفتاحية : طاقة ، فيتامين ج ، دجاج اللحم ، مناخ حار ، زيت الذرة.