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THE EFFECTS OF HIGH DIETARY ENERGY AND DIFFERENT LIGHT REGIMES ON THE PERFORMANCE OF BROILERS RAISED AT HIGH TEMPERATURE

By

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ABSTRACT

THE EFFECTS OF HIGH DIETARY ENERGY AND DIFFERENT LIGHT REGIMES ON THE PERFORMANCE OF BROILERS RAISED AT HIGH TEMPERATURE

By

Abubaker Abed El-Oraiby

An experiment was conducted to study the effects of high energy level diets on the performance of commercial broiler type birds raised in a high temperature environment.

Included were two test diets which contained 3410 or 3080 kcal. M.E./kg metabolizable energy, two temperature treatments either normal (20^{0}C) or high (31^{0}C), and two light regimes, continuous or intermittent light (14L and 10D). The experimental treatments were started when the birds reached 3 weeks of age and lasted for 10 weeks. Data were collected on 8 week and 10 week old birds.

The high energy diet significantly ($P \leq .01$) increased the body weight gain and feed efficiency of birds from 3 to 10 weeks of age. The different light treatments had no significant effect on the body weight gain of birds from 3 to 10 weeks of age. Chickens raised in intermittent light had significantly better feed efficiency than those raised in continuous light from 3 to 10 weeks of age.

The mortality of birds after the 10 week study was not great; but there was a significantly greater ($P \leq .05$) mortality in the group of birds that received the high energy diet.

DEDICATION

To my family, my wife Nadia and my son Osama, for their patience and understanding during the course of this work.

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INTRODUCTION

In 1947, Scott *et al.* demonstrated that high levels of energy are desirable in broiler rations. Since that discovery, an extensive amount of research has been conducted with poultry to determine the influence of high energy feed on growth rate, feed efficiency and the relationship between added fats in the feed and other nutrients. That is true if the chickens are raised under normal temperature and normal light regimes. However, formulas for broiler feeds must be changed as temperature changes. These formula changes are based on the assumption that the amount of feed consumed by the broiler is determined by their need for energy. During cold weather, extra energy is needed to maintain body temperature; therefore, chickens increase feed intake to meet this requirement. Nutritionists change the nutrient content of feed in an attempt to compensate for differential intakes during summer and winter. When these changes are made, it is assumed that the feed is balanced to meet the need of the chickens.

Some poultry researchers report that chickens do not regulate feed consumption to the extent needed for proper energy intake. They conclude that chickens adjust feed intake only to meet their appetite, not to meet their energy requirements. During extremely hot weather the chickens' appetite decreases, therefore the chicken does not consume enough feed to support maximum performance. At moderate temperatures the chickens' feed intake is better adjusted to meet their energy needs for optimum performance.

The objectives of this study was to determine whether a high energy diet and different light treatments are able to improve the weight gain, feed consumption, and mortality rate of chickens raised in a high mortality rate of chickens raised in a high temperature environment.

LITERATURE REVIEW

Fats and oils are practically all substances that are ether-extractable from feeds or tissue. Fats are those glycerol esters which are solids, while oils are liquids at ordinary temperatures. From a nutritional point of view, only linoleic acid is an essential fatty acid. The importance of linoleic acid for bird growth and hatchability, egg size and maximum egg production have been reported by many researchers (Thomasson, 1962; Menge *et al.*, 1965; and Menge, 1968). Lipids are added to the poultry diet primarily as a source of energy. They contain fat soluble vitamins and also help in their absorption. Fats act as a lubricant to facilitate the passage of feed; they reduce dustiness of feed and increase the palatability of the feed.

It has been known for many years that an increase in the energy content of poultry diets results in a decreased feed intake and improved performance in broilers (Donaldson *et al.*, 1956; and Waldroup *et al.*, 1976) and in laying hens (Jones *et al.*, 1976). Fraps (1928, 1944) and Scott *et al.* (1947) were among the first nutritionists to evaluate different feed as to their ability to support growth in chickens as a function of protein and fat deposition in the carcasses. They indicated that growth rate and efficiency of feed utilization were improved by feeding diets high in digestibility and energy concentration. Siedler *et al.* (1955) showed that addition of vegetable oil (not beef tallow) to the chicken diet will improve the efficiency of feed utilization. These results are similar to those of Renner and Hill (1960) and

Matterson *et al.* (1965), who indicated in their evaluation studies that, in general, vegetable oil was characterized by higher absorbability and higher metabolizable energy (M.E.) values than was animal fat.

Scott *et al.* (1976) indicated that fats included in the diet increased the utilization of feed as compared with that of a low fat diet. This improvement in energy efficiency can be attributed to a lowered heat increment with the diets that contained fat. This phenomenon has been called "associative dynamic action of fats".

It has been recognized that poultry do not regulate feed intake to the extent needed for proper energy intake, and do not eat to meet their energy requirements, but to meet their appetite. Gutteridge (1946) reported that the addition of 5% of animal fat to a poultry ration increased the rate of gain and improved the quality of the carcass. Slinger *et al.* (1952) found that the addition of soybean oil to the chickens ration increased growth slightly and improved the feed efficiency. Yacowitz (1953) and Sunde (1954b) have also shown that fat added to broiler rations at levels up to 5% improved the performance of the birds. Siedler *et al.* (1953) added 2, 4, 6 and 8% stabilized white grease, respectively, to a practical basal ration fed to growing birds. The rate of gain when fat was added was equal to or slightly higher than when the basal ration was fed. Feed efficiency increased with the increase in the level of fat. Sunde (1954a) fed white grease, prime tallow, or soybean oil at levels of 2.2 and 5% to birds and poults. No consistent increase in the rate of gain was observed with birds, but a slight improvement was noted when prime tallow was fed to turkey poults. Feed efficiency was increased with both birds and turkey poults. Jackson *et al.* (1969) fed diets with up to 28.25% added tallow at constant calorie:protein ratios. Feed conversion decreased with increased dietary fat. However, the efficiency of metabolizable energy utilization decreased with added tallow. The average daily M.E. consumption of birds fed the high tallow diet was 354 kcal. in comparison with 250 kcal. for those birds fed a comparable diet without added fat but with equivalent egg production and average egg weight. Scott *et al.* (1947) demonstrated that both growth rate and feed efficiency utilization were improved by feeding diets high in digestibility and energy concentration. Siedler *et al.* (1955) showed improved efficiency of feed utilization with the addition of beef tallow or vegetable oils to the diet of birds. This was also reported by Sunde (1954a), Aitkem *et al.* (1954), and Matterson *et al.* (1955). Waldroup *et al.* (1976) found that as the nutrient density level of the diet increased, bird body weights were increased. Total feed consumption tended to decrease with increasing nutrient density levels and the total energy consumption increased as the nutrient density level of the diet increased; gain:feed ratios were improved as the nutrient density levels of the diet increased. Sell and Thompson (1965) found that feeding low fat rations in the form of pellets or ground pellets increased weight gain, feed consumption and improved efficiency of food utilization. However, 10% fat in the ration increased weight gain only slightly and failed to increase feed consumption or to improve efficiency of food utilization. Further studies involving high fat rations for chickens were conducted by Combs *et al.* (1958); they found that marked differences were obtained in the value of various fats when compared with starch as a source of energy. They found that 10 and 18% supplemental fat may be used successfully in practical feeds. The addition of 10% fat slightly improved eight week weight in broilers receiving all mash but not in those receiving pelleted feeds. Feed conversion improved in proportion to the increased energy potency of the rations.

Reiser and Pearson (1949) used lard and hydrogenated vegetable oils in bird starter rations and the addition of these fats resulted in no deleterious effects on the growth of birds. Siedler *et al.* (1953) reported that the performance of birds fed added levels of fat was equal to, or better than, that of birds fed a ration without added fat. Fuller and Rendon (1976) conducted two experiments to determine the energy efficiency of diets containing different feed grade fats for the growth of broiler birds during the finishing period. They found that energy and nutrient intake were higher for all diets containing fats, indicating that feed intake was influenced by the heat increment (H.I.) of the diet as well as by energy level.

Daghin (1973) reported on three experiments conducted in Egypt, employing diets ranging from 2.28 to 2.92 kcal. M.E./g. These studies indicated improvement of feed conversion and reduced feed intake with higher performance of hens during warm weather. Douglas and Harms (1977) found that the addition of 2% animal fat and 1/2 lb. of methionine per ton resulted in an increase in feed intake. They also reported (1976b) that a certain change in the diet of laying hens and pullets would improve the performance of hens during hot weather. According to Harms *et al.* (1978), low temperature resulted in an increase in the birds' intake of energy, more than necessary for optimum performance. They found that at moderate temperature, the chickens eat to meet energy for optimum performance, but in hot temperature do not eat to support maximum performance.

Reid and Weber (1975) found that temperature had an effect on increased M.E. consumption in the presence of dietary fat. They found that birds housed in a conventional cage house significantly increased M.E. consumption with increasing levels of supplemental fat, while the birds in the evaporated cooled house did not. They concluded that the energy intake regulatory mechanisms are not adequately operative under high temperature conditions; or, more likely, that the effects of heat increments were magnified by high temperature and can be offset by high fat levels. Their finding was in agreement with the work by Jackson *et al.* (1969) in which daily M.E. consumption was increased from 250 to 354 kcal. per day with the feeding of 28.25% added tallow. Jackson *et al.* (1969) indicated that in a climate where a cooled housing is not commonly used, supplemental fat in a diet could be expected to result in improved performance during periods of high temperature.

Jones and Barnett (1974), in five experiments, determined that turkey hens in egg production required one to eight days to adjust feed consumption in 4.5^{0}C environmental temperature and eight to fourteen days in 35^{0}C temperature. There was no significant difference in feed consumption due to dietary energy level after the hens were acclimatized to the environmental temperature. However, Guenthner *et al.* (1972) reported that increasing the dietary energy fed to S.C. White Leghorn hens significantly decreased feed consumption, improved feed conversion and increased feed cost per dozen eggs; whereas, the rate of egg production was not affected.

Jones *et al.* (1976) reported that there was no significant difference in feed consumption among hens housed at cool (4.5 ± 1^{0}C) or moderate (21 ± 1^{0}C) temperature. However, hens housed in a hot temperature

(35 ± 1^{0}C) ate significantly less feed than hens housed at a cool temperature. Egg production was significantly less for hens in high environmental temperature when compared to hens confined in the low temperature environment. The hens housed at a control temperature of 21 ± 1^{0}C produced at the same rate as the hens housed in both the higher and lower temperature. Hens in the 35 ± 1^{0}C environment did not consume enough feed to maintain body weight. They lost significantly more weight than hens in the other treatment groups.

Miller and Sunde (1975) and deAndrade *et al.* (1976) reported that mild heat stress improved feed efficiency while reducing egg production and quality. deAndrade *et al.* (1976) found that feed conversion was improved with high temperature and the best conversion was noted in the 31^{0}C environment. A high nutrient density diet (HND) (25% more of all nutrients except energy which was increased 10%) increased egg production only at high temperatures and egg production of hens fed the HND diet at an elevated temperature approached normal egg production. Food consumption was decreased and feed efficiency was improved.

Huston and Edwards (1961) designed an experiment to determine the influence of protein and energy levels upon growth and feed efficiency of immature fowl held at different environmental temperatures. They found that the body weights were lower at the high environmental temperature than at either of the other temperatures. Less feed was required per pound of gain at the high temperature. The ration with the higher protein and energy values produced heavier birds in all environments.

Lillie *et al.* (1976) reported that the best overall performance in Leghorn pullets was obtained with a temperature of either 13^{0}C or 21.5^{0}C and with a dietary energy level of 2648 kcal. M.E./kg. Feed intake per hen per day was equivalent at 13^{0}C and 21.5^{0}C and significantly greater at these temperatures than at 29.5^{0}C. The fact that feed intake decreases at high temperatures is well documented, as shown by Warren and Schnepel (1940) with a temperature of 15.2^{0}C versus 34.5^{0}C, Ahmed *et al.* (1974) with 23^{0}C versus 30^{0}C, deAndrade *et al.* (1974) with 21^{0}C versus 32^{0}C and Jones *et al.* (1976) with 21^{0}C versus 35^{0}C.

Thomason *et al.* (1976) studied the effects of environmental factors on the reproductive performance of young turkey hens. They found that a constant temperature of 29.4^{0}C reduced egg production and lowered body and egg weight. They also reported that feed consumption decreased with increasing pen temperature. They suggested that optimum reproductive performance can be obtained with breeder turkeys when environmental temperatures are maintained between 12.8^{0}C and 21.1^{0}C. Thomason *et al.* (1972) reported that the maintenance of young turkey hens in a constant temperature environment of 29.4^{0}C caused lower egg and body weights and reduced feed consumption when compared with females maintained at a temperature of 12.8^{0}C and 21.1^{0}C.

Casey *et al.* (1974) found that the incidence of encephalomalacia in commercial broilers appeared to be associated with extended storage of starter feed at high temperature. The results suggested that field storage of feed at high temperature may affect performance of broilers.

Deaton and Reece (1970) found that a light-temperature interaction existed for broiler body weight gain. They found that broilers attained greater body weight gains at high varying temperature when given the opportunity to consume feed and water in the lower portion of the temperature cycle than when they had the opportunity to consume feed and water in the high portion of the temperature cycle through six weeks of age. Birds receiving light in the high portion of temperature cycle consumed practically the same amount of feed as birds receiving light in the lower portion of the temperature cycle.

Skoglund *et al.* (1964) found that birds consumed more feed when given a longer light period. They reported that this did not necessarily mean they would weigh significantly more than those on a shorter light period. When the light period was uninterrupted, then the normal day length of 12 hours was sufficient for maximum broiler growth. Buckland *et al.* (1973) found that broilers, exposed to light regimen of one hour light to three hours dark (1L:3D), were heavier at eight weeks of age than comparable birds given continuous light. Similar results were reported by Proudfood (1975) while Beane and Siegle (1965) found that optimum growth and feed conversion were attained with birds kept on continuous light as compared to light regimes of less than 24 hours of light per day. Moore (1957) has reported that chicken broilers grew best under continuous, or near continuous light to 4 weeks of age, and thereafter required less light to market age (8 to 10 weeks). Shutze *et al.* (1959) found that chicken broilers grew equally well under continuous light or six cycles of intermittent 2L:2D per 24 hours. Similar results were reported by Cherry and Barwick (1962) who found that under commercial broiler conditions, optimum weight and feed conversion were obtained with near continuous lighting, or with patterns involving 2 hours darkness or less per cycle.

Buckland and Hill (1970) reported that birds on intermittent light were slightly heavier than those on continuous light; however, Buckland *et al.* (1971) reported that the use of continuous light generally resulted in larger birds at two weeks than did intermittent light.

They concluded that birds under intermittent light did not have sufficient time to consume adequate quantities of feed, especially on low density ration.

Barrott and Pringle (1951), Clegg and Sanford (1951), Marr *et al.* (1971), McDaniel (1972), Cain (1973), Hooppaw and Goodman (1976), and McDaniel *et al.* (1977) found that birds grew better under intermittent light as compared to birds under continuous light. Weaver and Siegel (1969) reported that male broilers grown under continuous lighting were significantly heavier at 56 days of age than males exposed to periods of darkness. Feed efficiency was nonsignificantly different among light regimens in their study. According to Foshee *et al.* (1970), the primary factor affecting the growth rate of broilers was the uniform distribution of activity periods throughout the 24 hour day. Gore *et al.* (1969) reported that an adequate dark period following feeding plays the dominant role in broiler growth.

Dorminey (1971) found that body weight and feed conversion of broilers grown in varying light periods and intensities compared satisfactorily with broilers grown in continuous light of normal intensity if the lights-on period was at least one hour and the lights-off period did not exceed two hours.

The effect of environmental conditions such as light and temperature on the performance of broiler chickens is still unclear and needs more investigation. Many different systems of lighting are used in commercial broiler houses at the present time. Light schedules may be continuous or interrupted. The effect of different light intensity, color and light regime on the performance of broiler chickens have been reported (Cherry and Barwick, 1962). However, other investigator results were inconclusive. Barrott and Pringle (1951) indicated that growth rate in the first 18 days was slightly lower with light intensity greater than six foot candles. However, Skoglund (1959) and others showed no consistent difference in bird growth rate with 15 or 120 foot candles.

It has been reported that a chicken eats to satisfy its energy requirements. However, at high temperature, it is not known whether a lower feed intake or some other physiological mechanisms caused the reduced growth rate. Huston and Edwards (1961) indicated that factors other than energy intake are involved in growth inhibition of birds at high environmental temperature. However, Sturkie (1976) reported that energy intake is affected by the environmental temperature and showed that gross energy intake increased linearly with decreasing environmental temperature. Most investigators have found that the feed consumption of chickens decreased when the environmental temperature was increased. However, during hot temperature the broilers or laying hens will eat just to satisfy their appetite, which is usually not enough to support their growth and production. So it is necessary to adjust the nutrient content of the diet according to the change of environmental condition to support a maximum performance in broilers.

MATERIALS AND METHODS

Six hundred day-old commercially hatched broiler type birds (approximately 300 of each sex) were wing banded and maintained with sexes separated in floor pen units with wood shaving litter. Gas heated brooders were used, and for the first two weeks flat type feeders and jar-waterers were employed, then replaced by hanging feeders and mechanical waterers. The birds were fed a standard starter ration from day one through three weeks of age. Feed and water were provided ad libitum. The composition and analysis of the starter diet used in this experiment is shown in Table 1.

At three weeks of age, the birds were sorted according to body weight categories (in grams) into the following groupings: Female 378-422, 423-447, 448-472, 473-500; Male 450-475, 476-500, 501-525, 526-550. Birds outside this range were discarded. Then selected birds were distributed into groups of nearly the same average weight. The birds were then divided into 16 experimental groups of 10 males and 10 females in each group and individual weights were recorded. There were 20 birds/group x 8 treatments x 2 replications for a total of 320 birds. The experiment lasted for 10 weeks. The temperature was the same in 8 of the pens (normal temperature about 20^{0}C); and the other 8 pens had a high temperature (about 31^{0}C). The birds received two different light regimes, intermittent and continuous light. Eight pens received intermittent light and the other eight pens received continuous light. The intermittent light was controlled by the use of

TABLE 1

Composition of Starter Diet

Diet Unit		%
Cornmeal		52.00
Soybean meal (49%)		33.60
Animal fat		5.10
Fishmeal		4.00
Alfalfa meal (17%)		2.50
Limestone		0.90
Dicalcium phosphate		1.10
Salt		0.42
DL-Methionine		0.13
Vitamin premix[3]		0.25
	TOTAL	100.00
Calculated Analysis:		
kcal. M.E./kg[1]		3190.00
crude fiber		3.10
total fat		7.70
xanthophyll		7.10
crude protein		24.07
energy:protein ratio[2]		132.50

[1]kilocalories of metabolizable energy per kilogram of diet.
[2]based on kcal. M.E./kg diet.
[3]see Table 4.

a time switch which turned off at 6:00 p.m. and on at 4:00 a.m., during the duration of the experiment to provide the birds with 14 hours of light and 10 hours of dark daily. Experimental design and allocation were as shown in Table 2.

Birds in one-half the pens were given a low energy diet A, that contained a total metabolizable energy (M.E.) of 3080 kcal. M.E./kg. The birds in the other pens received a high energy diet B, that contained a M.E. of 3410 kcal. M.E./kg (see Table 2). Birds in pens number 1, 3, 5, and 7 received diet A; while the birds housed in pens number 2, 4, 6, and 8 received diet B. The composition and analysis of the experimental diets are shown in Table 3.

Feed was mixed at the Michigan State University Poultry Science Research and Teaching Center, and weighed at the beginning and at the end of each experimental period. Feed consumption was measured and mortality was recorded throughout the experiment and computed for the periods 3 to 8 and 3 to 10 weeks of age. During the fourth week of age, swollen hocks and lameness were observed in birds in a number of pens. Some of the birds died from starvation because they could not reach the food and water. Some of the birds that had swollen hocks and lameness were sent to the M.S.U. Animal Health Diagnostic Laboratory, but no cause for the condition could be determined. To alleviate any possibility of a borderline vitamin deficiency, the remaining feed was collected and more vitamin premix was added to it. Thus, from four to ten weeks of age, the diet used contained 0.5% vitamin premix. The formula for Michigan State starter-grower vitamin premix No. 5003, which was the one used in these diets, is shown in Table 4.

TABLE 2

Experimental Design and Allocation

A	1	NC	1
B	2		2
A	3	NI	3
B	4		4
A	5	HC	5
B	6		6
A	7	HI	7
B	8		8

NC = Normal temperature, continuous light
NI = Normal temperature, intermittent light
HC = Hot temperature, continuous light
HI = Hot temperature, intermittent light
A = Diet No. A (3080 kcal./kg)
B = Diet No. B (3410 kcal./kg)

TABLE 3

Composition of Experimental Diets

Diet No. Unit	A %	B %
Cornmeal	63.50	48.00
Soybean meal (49%)	25.70	33.10
Animal fat	1.60	9.20
Fish meal	4.00	4.00
Alfalfa meal (17%)	2.50	2.50
Limestone	0.40	1.00
Dicalcium phosphate	1.00	1.30
Salt	0.40	0.50
DL-Methionine	0.20	0.21
Vitamin premix[1]	0.50	0.50
TOTAL	100.00	100.00
Calculated Analysis:		
kcal. M.E./kg[2]	3080.00	3410.00
crude fiber (%)	3.10	2.90
total fat (%)	4.70	11.70
xanthophyll, mg/kg	3.80	3.05
crude protein (%)	21.24	23.60
energy:protein ratio[3]	145.00	144.74

[1]see Table 4.
[2]kilocalories of metabolizable energy per kilogram of diet.
[3]based on kcal. M.E./kg diet.

TABLE 4

Michigan State
Starter-Grower Vitamin Premix No. 5003
(with Ethoxyquin)

Micronutrients	Per Kilogram of Starter-Grower
Vitamin A, U.S.P. units	8250.00
Vitamin D_3, I.C. units	2750.00
Riboflavin, mg	5.10
Pantothenic Acid, mg	8.30
Niacin, mg	24.80
Choline Chloride, mg	550.00
Vitamin B_{12}, mg	12.40
Menadione Sodium Bisulfite, mg	2.10
Vitamin E, I.U.	2.10
Manganese, mg	80.00
Iodine, mg	1.30
Copper, mg	5.00
Cobalt, mg	312.00
Zinc, mg	61.50
Iron, mg	31.20

The body weight, feed consumption, and mortality of birds were recorded. The average weight gain, average feed consumption, and feed conversion were calculated for each group. There were 16 groups of birds composed of duplicate combinations of high and low energy diet, continuous and intermittent light, normal and high environmental temperature. Each group was analyzed separately for birds 3 to 8 weeks and 3 to 10 weeks of age.

Statistical Procedure

Significance of variation in growth, feed consumption and feed efficiency were tested by analysis of variance using a M.S.U. Hustler computer. The 0.01 or 0.05 levels of probability provide the basis for all statements concerning statistically significant difference.

RESULTS AND DISCUSSION

Body Weight

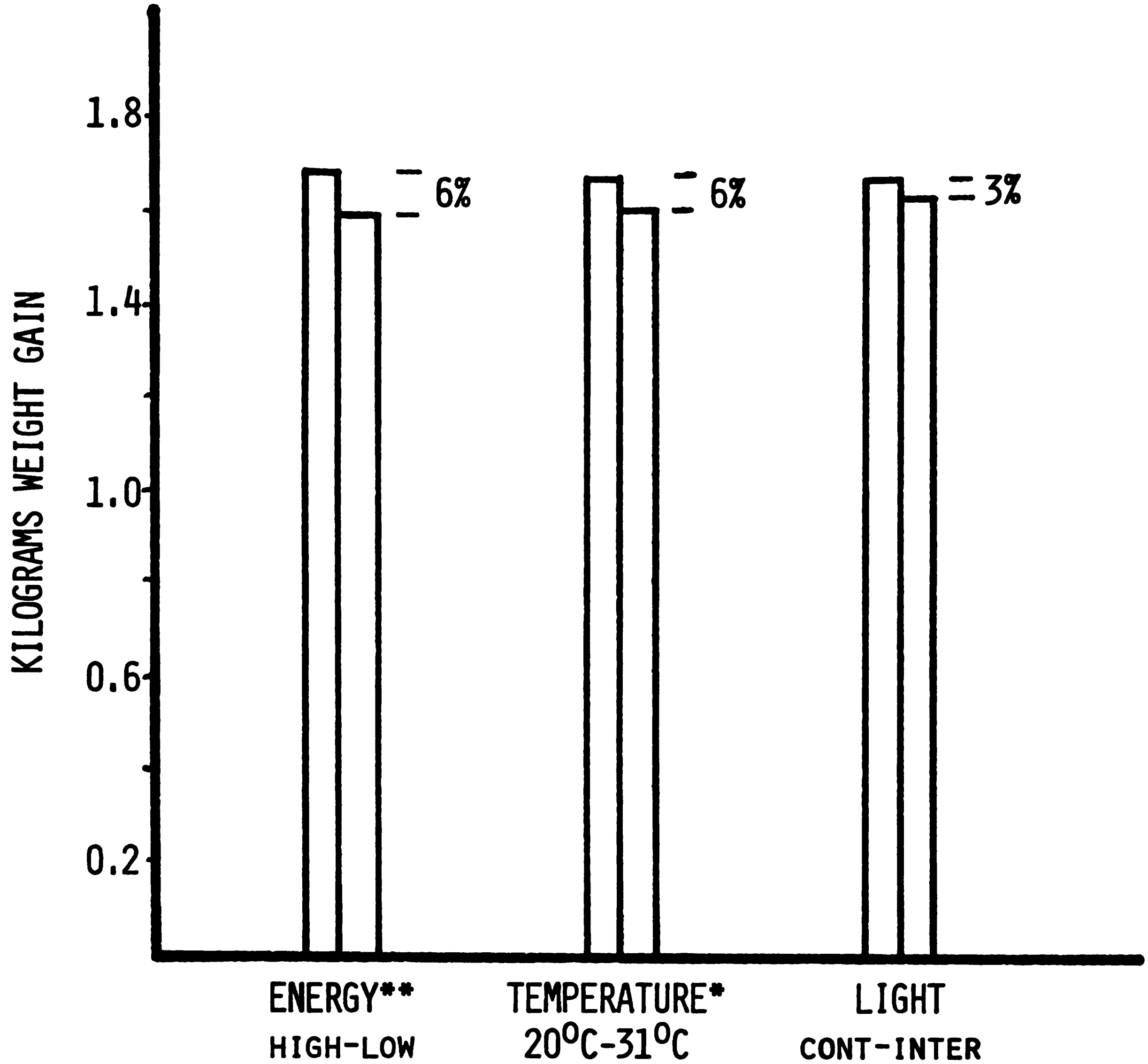
The body weight gain of birds from 3 to 8 weeks of age are shown in Table 5. From Table 5, it is evident that the birds in the lot fed the high energy diet and raised under normal temperature and continuous light gained more weight (1827 g) than did birds in other lots.

This result would be expected by examination of Figure I. As illustrated in Figure I, the factors of high energy, normal temperature, and continuous light produced the greatest body weight gain. The birds in this treatment group would be expected to have the greatest weight gain. Using similar reasoning, the group with the lowest body weight gain would be expected from the birds receiving the treatments with the least body weight gain (low energy, high temperature, intermittent light) from Figure I. From Table 5, the lowest weight gain of 1537 g was from this group.

A high energy diet was responsible for the largest body weight gain as compared with all other variables tested. The difference in the body weight gain of the high and low energy diet was statistically significant ($P < .01$).

Normal environmental temperature significantly increased ($P < .05$) the body weight gain when compared to a high temperature environment.

In three out of the four possible comparisons in Table 5, the birds raised in continuous light had a greater body weight gain than those raised in intermittent light. Also, in Figure I there is a difference



CONT = CONTINUOUS
INTER = INTERMITTENT
SIGNIFICANCE:
$*P \leq 0.05$
$**P \leq 0.01$

FIGURE I

AVERAGE BODY WEIGHT GAIN OF BIRDS IN KILOGRAMS FROM 3 TO 8 WEEKS OF AGE.

TABLE 5

Average Body Weight Gain in Grams of Birds from 3 to 8 Weeks of Age[1]

Temperature	Treatment	Average Gain for Period
20^0C	LC	1622^a
	LI	1627^a
	HC	1827^b
	HI	1649^a
31^0C	LC	1570^a
	LI	1537^a
	HC	1642^a
	HI	1641^a

L = low energy (3080 kcal. M.E./kg)
H = high energy (3410 kcal. M.E./kg)
C = continuous light
I = intermittent light

[1]Means with different postscripts differ significantly ($P < .05$)

of 3% between the two variables. Although birds raised under continuous light appear to have a greater body weight gain no statistically significant difference was found.

Analysis of variance was used to study the effect of each variable and its interaction with the other variables on body weight gain of birds from 3 to 8 weeks of age. As shown in Table 6, there was no interaction between the three variables of energy, temperature, and light. Energy and temperature were the only significant factors affecting the body weight gain. The light regime had no significant effect.

Table 7 shows the body weight gain for birds in 8 treatments from 3 to 10 weeks of age. The greatest body weight gain of 2458 g was in the group of birds that received the high energy diet, raised at high temperature and continuous light. The high energy diet was again responsible for the greatest body weight gain as illustrated in Figure II. The 7% difference between high and low energy diets of birds from 3 to 10 weeks of age was slightly greater than the 6% difference in the body weight gain of birds from 3 to 8 weeks of age due to diet. The 1% and 3% difference in the body weight gain of birds raised in normal versus high temperature and continuous versus intermittent light were not statistically significant. Again, as with birds from 3 to 8 weeks of age, there was no statistically significant interaction between the 3 factors: energy, temperature, and light as seen in the analysis of variance, Table 8. Energy was the only significant factor affecting the body weight gain of birds from 3 to 10 weeks. Temperature and light had no significant effect.

The literature consistently supports our finding that a high energy diet increased body weight gain. Siedler *et al.* (1953) reported that

TABLE 6

Analysis of Variance of Bird Weight Gain
from 3 to 8 Weeks of Age

Source of Variance	Sum of Squares	Degree of Freedom	Mean Square	F Value
Energy	40768.66	1	40768.66	13.84**
Light	10781.19	1	10781.19	3.66
Temperature	28092.27	1	28092.27	9.54*
Energy & Light	5712.71	1	5712.71	1.94
Energy & Temperature	644.52	1	644.52	.22
Light & Temperature	4742.73	1	4742.73	1.61
Energy & Light & Temperature	11682.91	1	11682.91	3.97
Error	23565.32	8	2945.66	
TOTAL	125990.32	15		

Significance:

*$p \leq 0.05$
**$p \leq 0.01$

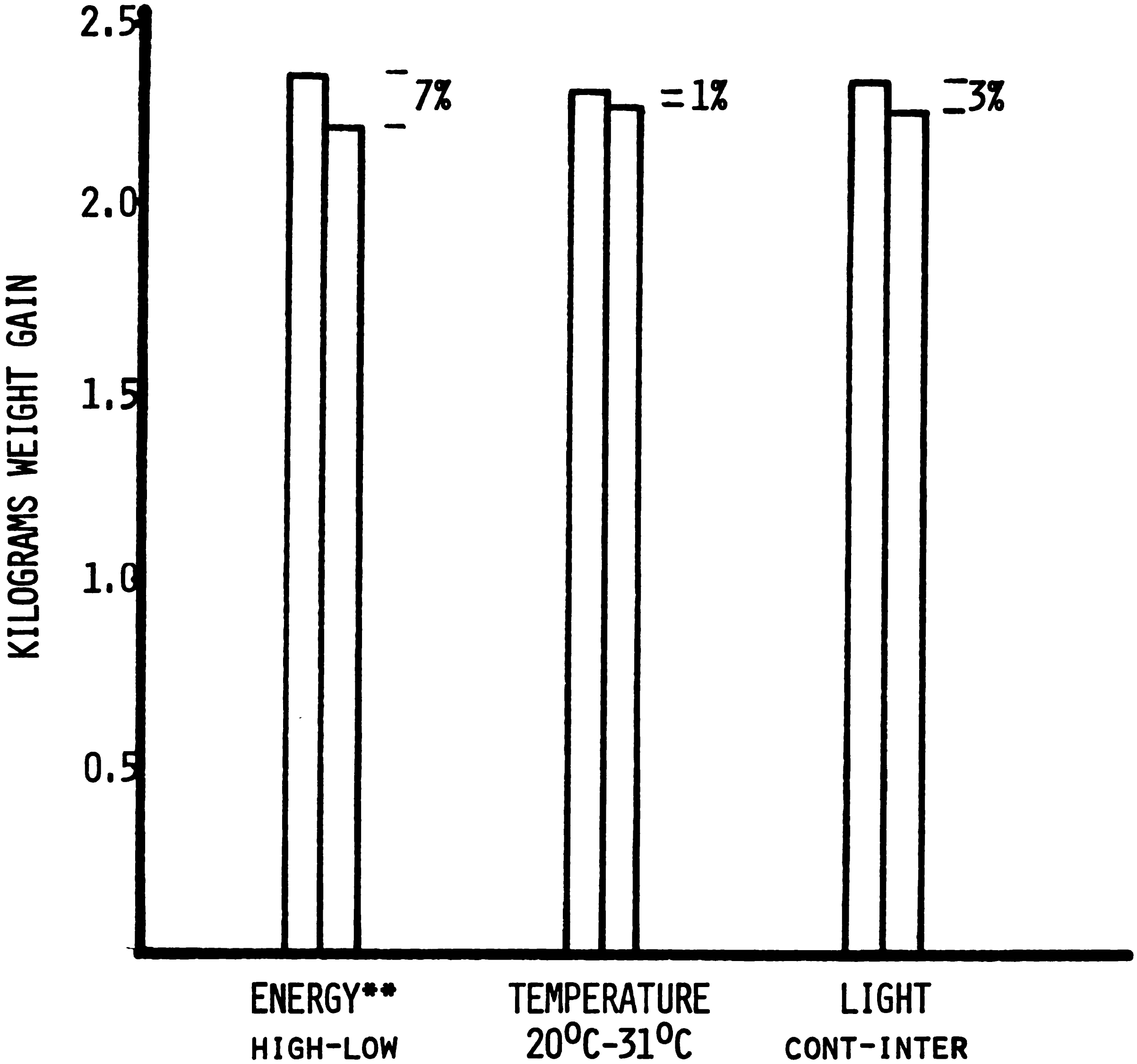
TABLE 7

Average Body Weight Gain in Grams of Birds from 3 to 10 Weeks of Age[1]

Temperature	Treatment	Average Gain for Period
20°C	LC	2214[ab]
	LI	2238[ab]
	HC	2434[ab]
	HI	2305[ab]
31°C	LC	2176[a]
	LI	2189[ab]
	HC	2458[b]
	HI	2240[ab]

L = low energy (3080 kcal. M.E./kg)
H = high energy (3410 kcal. M.E./kg)
C = continuous light
I = intermittent light

[1]Means with different postscripts differ significantly ($P < .05$)



CONT = CONTINUOUS
INTER = INTERMITTENT
SIGNIFICANCE:
**$P \leq 0.01$

FIGURE II

AVERAGE BODY WEIGHT GAIN OF BIRDS IN KILOGRAMS FROM 3 TO 10 WEEKS OF AGE.

TABLE 8

Analysis of Variance of Bird Weight Gain
from 3 to 10 Weeks of Age

Source of Variance	Sum of Squares	Degree of Freedom	Mean Square	F Value
Energy	95920.28	1	95920.28	13.17**
Light	23938.28	1	23938.28	3.29
Temperature	4158.96	1	4158.96	.57
Energy & Light	27167.98	1	27167.98	5.10*
Energy & Temperature	503.10	1	503.10	.07
Light & Temperature	2467.11	1	2467.11	.34
Energy & Light & Temperature	1524.90	1	1524.90	.21
Error	58274.87	8	7284.90	
TOTAL	223955.49	15		

Significance:

*P < .05
**P < .01

body weight gain of birds fed added levels of fat was equal to or better than that of birds fed rations without added fat up to 9 weeks of age. Waldroup *et al.* (1976) reported that as the energy level of the diet was increased, bird body weights were increased. Experiments by Huston and Edwards (1961) indicated that the body weight gains in birds were increased with high energy diets at both 19^0C and 31^0C environmental temperature. From our results, birds raised at 20^0C gained more weight than those raised at 31^0C from 3 to 8 weeks; whereas no significant difference was found from 3 to 10 weeks. Huston and Edwards (1961) reported body weight gains were lower at a high environmental temperature (31^0C) than at a lower temperature (19^0C). This supports our findings in birds from 3 to 8 weeks of age. Similarly, Thomasson *et al.* (1976) found that a high temperature of 29.4^0C reduced the body weight of turkeys in 8 weeks. An explanation of these findings was given by Harms *et al.* (1978) who states that in extremely hot weather birds do not consume enough feed to support maximum performance.

Continuous and intermittent light patterns had no significant effect on body weight gain in our study. This result was supported by the work of Cherry and Barwick (1962), who found that different lighting patterns had no important effect on the body weight of broilers at 10 weeks of age. Moore (1957) found that chickens kept in continuous light grew faster than those given periods of darkness. This result was suggested by our data from Figure I and II where birds from 3 to 8 and 3 to 10 weeks of age had a 3% and 1% increase in weight respectively; although this increase was not statistically significant.

Feed Consumption

The data on the average daily feed consumption in grams/bird/day from 3 to 8 weeks of age are presented in Table 9. The different dietary energy, environmental temperature, and light treatments had a highly significant ($P < .01$) effect on feed consumption (Table 10).

The dietary energy level of the feed appeared to have a greater effect on feed consumption than did either temperature or light treatment (Figure III). Chickens consumed approximately 21% more low energy feed (3080 kcal. M.E./kg) than high energy feed (3410 kcal. M.E./kg). This increase may be explained in part by the fact that more low energy feed is required to supply the same amount of calories as that supplied by the high energy feed. Although this probably accounts for much of the increased consumption of the lower energy feed, it does not seem to account for the entire increase.

The high energy feed contains about 10% more calories than the low energy feed. Therefore, the birds on the low energy diet would have to consume only 10% more feed to obtain the same amount of calories as those on the high energy feed, but they consumed 21% more feed. This leave about one-half of the increased feed consumption of the birds on a low energy diet unexplained.

Feed consumption was decreased about 12% at the higher temperature and 10% with intermittent light (Figure III). This is probably because the birds at the lower temperature (20^{0}C) had to use more energy to maintain their body temperature of 41^{0}C.

Chickens are more active in continuous rather than intermittent light conditions; therefore, it would be expected that more feed would be consumed by chickens raised in continuous light. Using the results

TABLE 9

Average Daily Feed, Protein and Calorie Consumption
of Birds from 3 to 8 Weeks of Age

Temperature	Treatment	Average Daily Consumption		
		Feed gm[1]	Protein %	Calories kcal./g
20^{0}C	LC	110.0^{e}	23.4	330
	LI	98.2^{d}	20.9	302
	HC	86.9^{c}	20.5	396
	HI	77.8^{b}	18.3	265
31^{0}C	LC	96.5^{d}	20.5	297
	LI	98.5^{c}	19.0	276
	HC	77.3^{b}	18.2	264
	HI	66.9^{a}	15.8	228

L = low energy (3080 kcal. M.E./kg)
H = high energy (3410 kcal. M.E./kg)
C = continuous light
I = intermittent light

[1]Means with different postscripts differ significantly ($P < .05$)

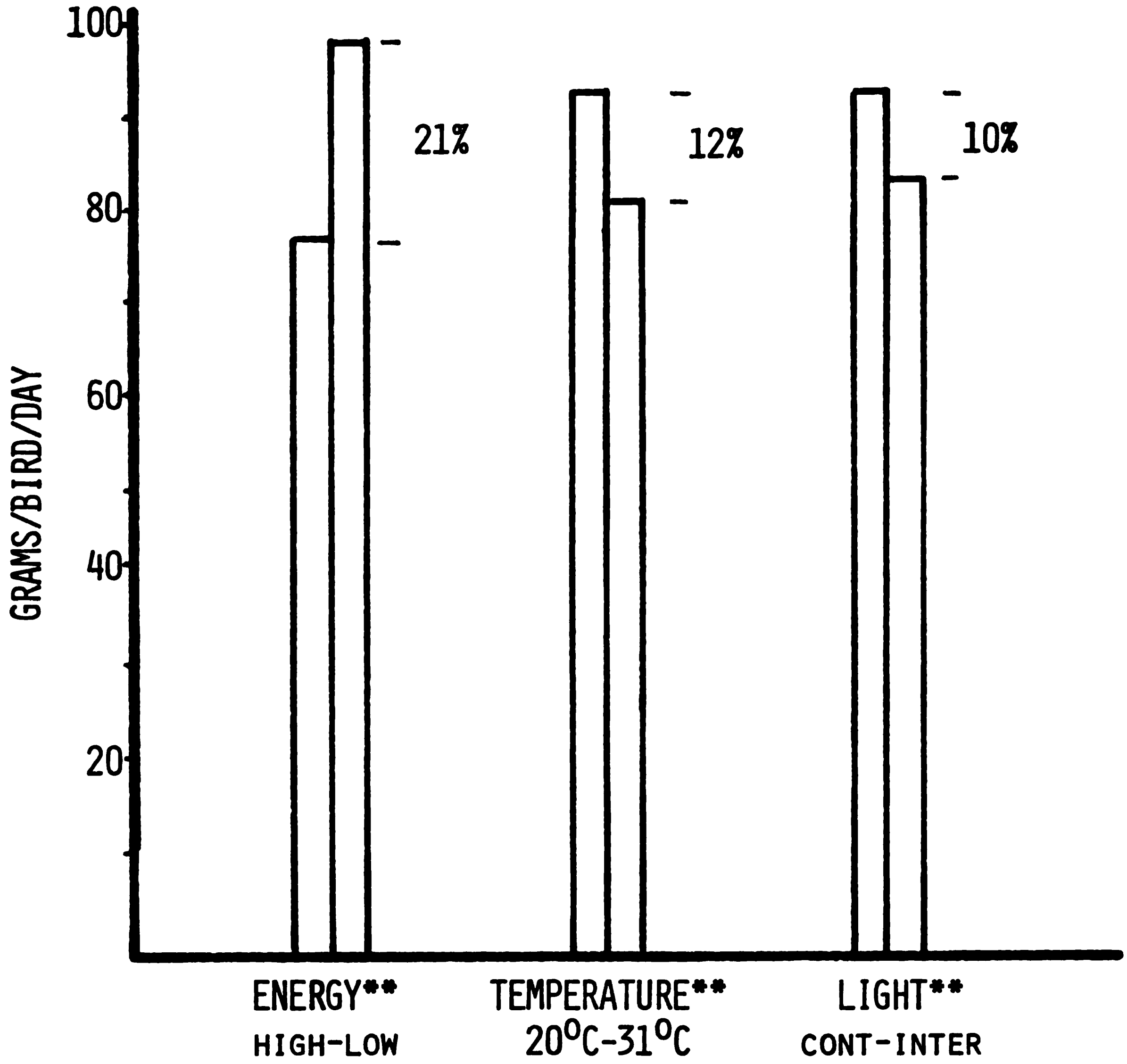
TABLE 10

Analysis of Variance of Food Consumption by Birds from 3 to 8 Weeks of Age

Source of Variance	Sum of Squares	Degree of Freedom	Mean Square	F Value
Energy	1819.96	1	1819.96	252.75**
Light	369.24	1	369.24	51.29**
Temperature	455.84	1	455.84	63.32**
Energy & Light	.09	1	.09	0.01
Energy & Temperature	1.02	1	1.02	0.14
Light & Temperature	3.18	1	3.18	0.44
Energy & Light & Temperature	9.60	1	9.60	1.13
Error	57.61	8	7.20	
TOTAL	2716.53	15		

Significance:

**$p \leq 0.01$



CONT = CONTINUOUS
INTER = INTERMITTENT
SIGNIFICANCE:
**P 0.01

FIGURE III

AVERAGE DAILY FEED CONSUMPTION OF BIRDS FROM 3 TO 8 WEEKS OF AGE.

in Figure III, one would expect the greatest amount of feed consumption from those birds in the group that received the low energy diet and raised at 20^{0}C in continuous light. From Table 9 the greatest consumption of 110 grams/bird/day was found in this group. Conversely, the lowest feed consumption would be expected from the birds in the group that received a high energy diet and were raised at 31^{0}C in intermittent light. This was confirmed in Table 9 with the lowest consumption of 67 grams/bird/day from this group.

When the effect on feed consumption of the different variables, energy, temperature and light were tested against each other; no statistically significant interaction was found (Table 10). Therefore, it appears that each variable acts independently of the others. The difference between the 3 factors of energy, temperature, and light were highly significant ($P < .001$).

The data on the average daily feed consumption by birds from 3 to 10 weeks are presented in Table 11. Again, as in the 3 to 8 week group the greatest feed consumption (120 grams/bird/day) was found in the group of birds receiving the low energy diet, raised at normal temperatures and continuous light. Conversely, the lowest feed consumption of 87 grams/bird/day was found in the group of birds that received a high energy diet, raised at high temperature and intermittent light. The 15% greater consumption of low rather than high energy diets by birds from 3 to 10 weeks of age was less than the 21% difference in consumption from 3 to 8 weeks of age (Figure IV).

There was a 6% difference in the feed consumption of birds raised in normal versus high temperature and in continuous versus intermittent light. This 6% difference was not statistically significant.

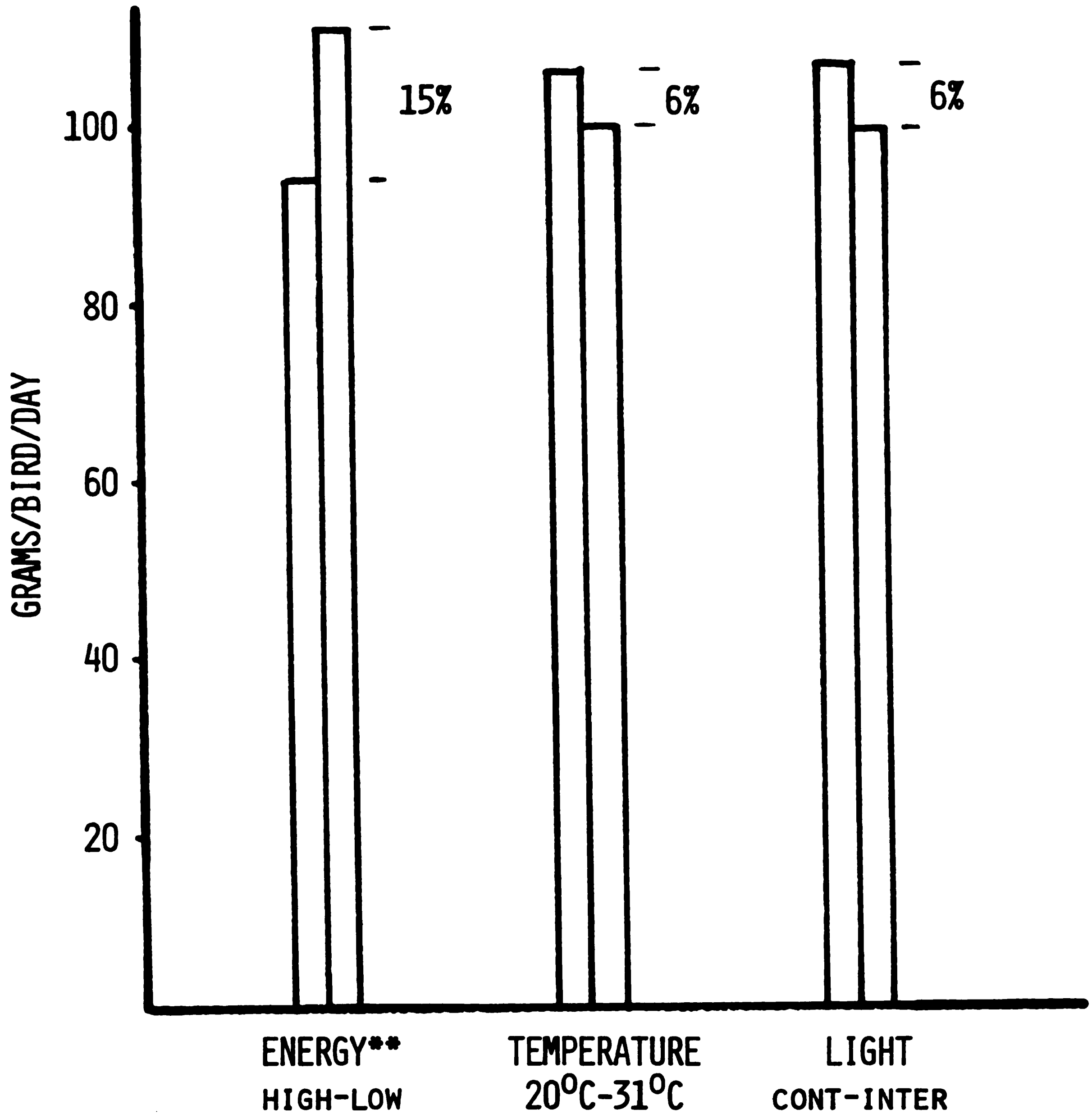
TABLE 11

Average Daily Feed, Protein and Calorie Consumption of Birds from 3 to 10 Weeks of Age

Temperature	Treatment	Average Daily Consumption		
		Feed gm[1]	Protein %	Calories kcal./g
20^0C	LC	119.8[b]	25.4	369
	LI	107.0[ab]	22.7	329
	HC	102.4[ab]	24.1	349
	HI	94.6[a]	22.3	323
31^0C	LC	108.7[ab]	23.1	335
	LI	108.6[ab]	23.1	334
	HC	92.6[a]	21.8	316
	HI	86.9[a]	20.5	296

L = low energy (3080 kcal. M.E./kg)
H = high energy (3410 kcal. M.E./kg)
C = continuous light
I = intermittent light

[1]Means with different postscripts differ significantly ($P < .05$)



CONT = CONTINUOUS
INTER = INTERMITTENT
SIGNIFICANCE:
**$P \leq 0.01$

FIGURE IV

AVERAGE DAILY FEED CONSUMPTION OF BIRDS FROM 3 TO 10 WEEKS OF AGE.

Again, as with birds from 3 to 8 weeks of age, there was no statistically significant interaction between the 3 factors; energy, temperature, and light (Table 12). Energy was the only factor which significantly ($P < .01$) affected feed consumption of birds from 3 to 10 weeks of age. This is different from the results obtained in birds from 3 to 8 weeks of age where all three factors (energy, temperature, and light) were significant.

deAndrade *et al.* (1976), Fuller and Randon (1976), and Reid and Weber (1975) agreed with our findings that a high energy diet significantly reduced feed consumption. Using the data of Waldroup *et al.* (1976), feed consumption of broiler birds from 0 to 56 days dropped about 6% when diets of 3080 kcal. M.E./kg (low energy diet) were compared to those of 3410 kcal. M.E./kg (high energy diet). Jones *et al.* (1976) found no difference in feed consumption with different dietary energy levels of 2671, 2853, and 2992 kcal. M.E./kg. This may be because these energy levels are substantually lower than those of 3080 and 3410 kcal. M.E./kg used in this study.

Thomasson *et al.* (1976) reported decreased feed consumption in turkeys with increasing temperature from 12.8 to 21.1 to 29.4^{0}C. This differential response to feed consumption was attributed to the different requirements of feed for body maintenance at the different temperatures. These results were the same as our findings of a significant effect of temperature on feed consumption in chickens from 3 to 8 weeks of age. Jones *et al.* (1976) also found that at high temperatures of 35^{0}C hens consumed significantly less feed than those at the control temperature of 21^{0}C. These results are further supported by deAndrade *et al.* (1976) who used temperatures of 21^{0}C and 31^{0}C.

TABLE 12

Analysis of Variance of Food Consumption by Birds from 3 to 10 Weeks of Age

Source of Variance	Sum of Squares	Degree of Freedom	Mean Square	F Value
Energy	1130.98	1	1130.98	21.91**
Light	179.41	1	179.41	3.48
Temperature	185.49	1	185.49	3.59
Energy & Light	.02	1	.02	.01
Energy & Temperature	14.44	1	14.44	.28
Light & Temperature	52.77	1	52.77	1.02
Energy & Light & Temperature	27.01	1	27.01	.52
Error	412.93	8	51.61	
TOTAL	2003.04	15		

Significance:

$**P < 0.01$

In this study, the results for chickens from 3 to 8 weeks of age were in agreement with those of Skoglund *et al.* (1964) who found that birds given a longer light period consumed more feed. The effect of light on feed consumption of birds from 3 to 10 weeks of age was not significant. The decreased importance of light on the feed consumption of older birds was described by Cherry and Barwick (1962). They found that as the age of the birds increased from 2 to 6 weeks the effect of light on feed consumption decreased.

Feed Efficiency

The feed efficiency of chickens from 3 to 8 weeks of age was best for the group of birds that received the high energy diet and raised at high temperature with intermittent light (1.43 grams feed/gram gain) (Table 13). This is more easily seen in Figure V, where it is shown that these same factors resulted in the greatest feed efficiency. Again, the opposing treatments of low energy, normal temperature, and continuous light resulted in the poorest feed efficiency in Figure V as well as in the group of birds raised under these three treatments (2.38 grams feed/gram gain) (Table 13).

Dietary energy levels produced the greatest difference in feed efficiency (26%). The birds receiving the high energy diet had the best feed efficiency (1.59 grams feed/gram gain) and those on the low energy diet had the least efficiency (2.16 grams feed/gram gain) of the six variables (see Figure V).

The differences between normal versus high temperature and continuous versus intermittent light of 7% and 8%, respectively, were only about 1/3 as great as that of dietary energy but they were still stignificant ($P < .01$).

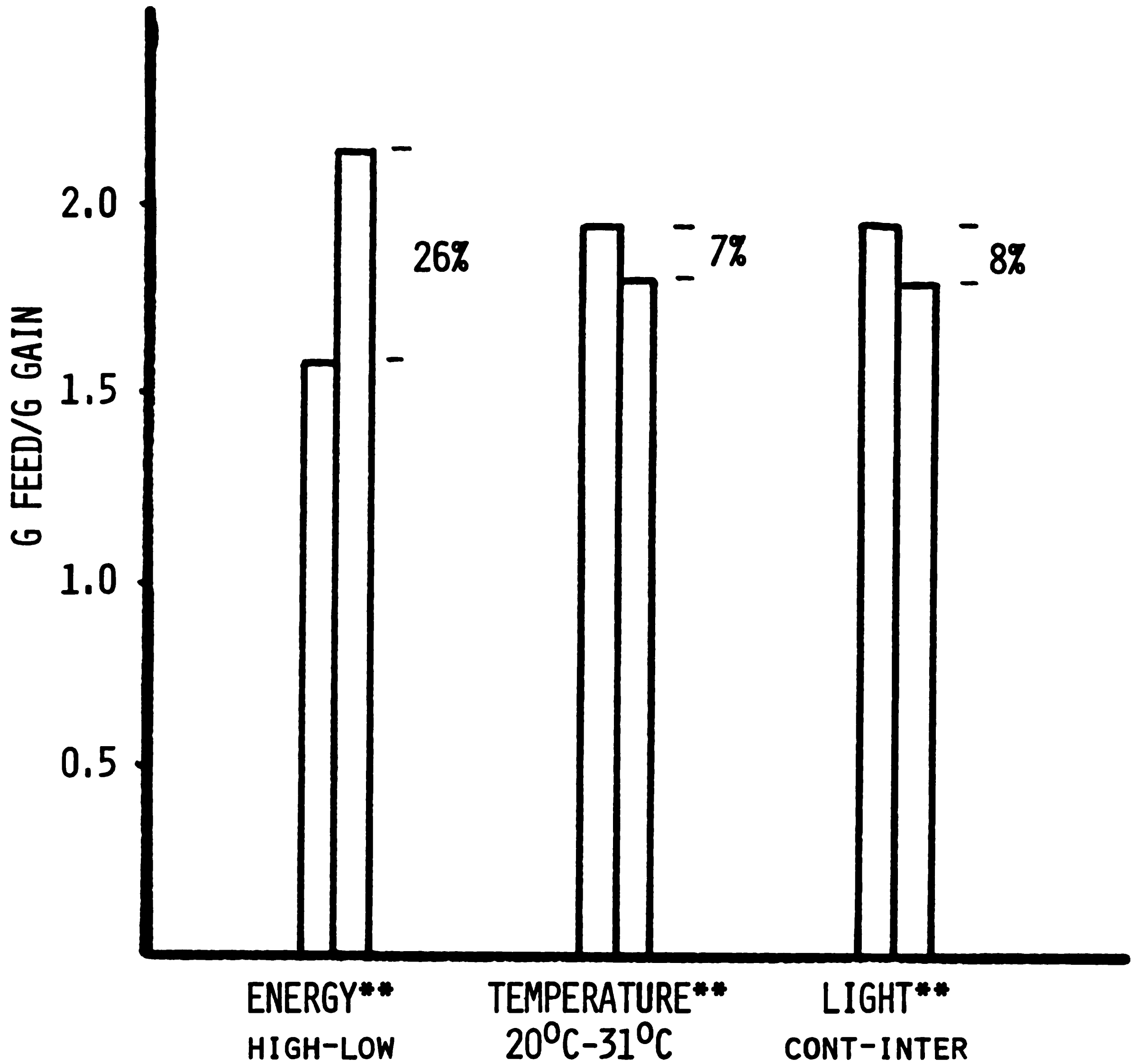
TABLE 13

Feed Efficiency of Birds from 3 to 8 Weeks of Age[1]

Temperature	Treatment	Feed Efficiency gm feed/gm gain
$20^{0}C$	LC	2.38^{d}
	LI	2.11^{c}
	HC	1.66^{b}
	HI	1.65^{b}
$31^{0}C$	LC	2.15^{c}
	LI	2.04^{c}
	HC	1.65^{b}
	HI	1.43^{a}

L = low energy (3080 kcal. M.E./kg)
H = high energy (3410 kcal. M.E./kg)
C = continuous light
I = intermittent light

[1]Means with different postscripts differ significantly ($P < .05$)



CONT = CONTINUOUS
INTER = INTERMITTENT
SIGNIFICANCE:
**P $\leq$ 0.01

FIGURE V

FEED EFFICIENCY IN GRAMS FEED/GRAMS WEIGHT GAIN FOR BIRDS FROM 3 TO 8 WEEKS OF AGE.

The analysis of variance (Table 14) showed a significant interaction between the three factors of energy, light, and temperature ($P < .05$) for birds from 3 to 8 weeks of age. Also shown in Table 14 is the significant difference in feed efficiency of each of the three variables tested ($P \leq .01$).

The feed efficiency for birds from 3 to 10 weeks of age was similar to that of the 3 to 8 week group (Table 15). Again, the best feed efficiency of the 8 treatment groups was found in those that received a high energy diet, raised at high temperature, and with intermittent light (1.90 grams feed/gram gain), and the best in those birds that received the low energy, normal temperature, and continuous light (2.65 grams feed/gram gain) treatment.

Although the dietary energy level again had the greatest effect on feed efficiency in birds from 3 to 10 weeks of age; the difference of 19% (Figure VI) was not as great as the 26% difference found in 3 to 8 week old birds.

The difference in feed efficiency due to environmental temperature was much less from 3 to 10 weeks of age than from 3 to 8 weeks of age. This 3% difference was not statistically significant.

Birds raised in intermittent light had a 6% greater feed efficiency than those raised in continuous light. This was slightly less than the 8% difference in feed efficiency due to light treatment found in the 3 to 8 week old group; although it was still statistically significant ($P < .05$). The analysis of variance of feed efficiency of birds from 3 to 10 weeks of age was different from that of the 3 to 8 week group. This time no interaction was found among the three variables (Table 16). Also, only the different energy and light treatment had a significant

TABLE 14

Analysis of Variance of Feed Efficiency in Birds
from 3 to 8 Weeks of Age

Source of Variance	Sum of Squares	Degree of Freedom	Mean Square	F Value
Energy	1.31	1	1.31	267.68**
Light	.09	1	.09	19.01**
Temperature	.07	1	.07	14.95**
Energy & Light	.01	1	.01	1.12
Energy & Temperature	.01	1	.01	.22
Light & Temperature	.01	1	.01	.14
Energy & Light & Temperature	.03	1	.03	6.77*
Error	.04	8	.01	
TOTAL	1.56	15		

Significance:

*P < 0.05
**P < 0.01

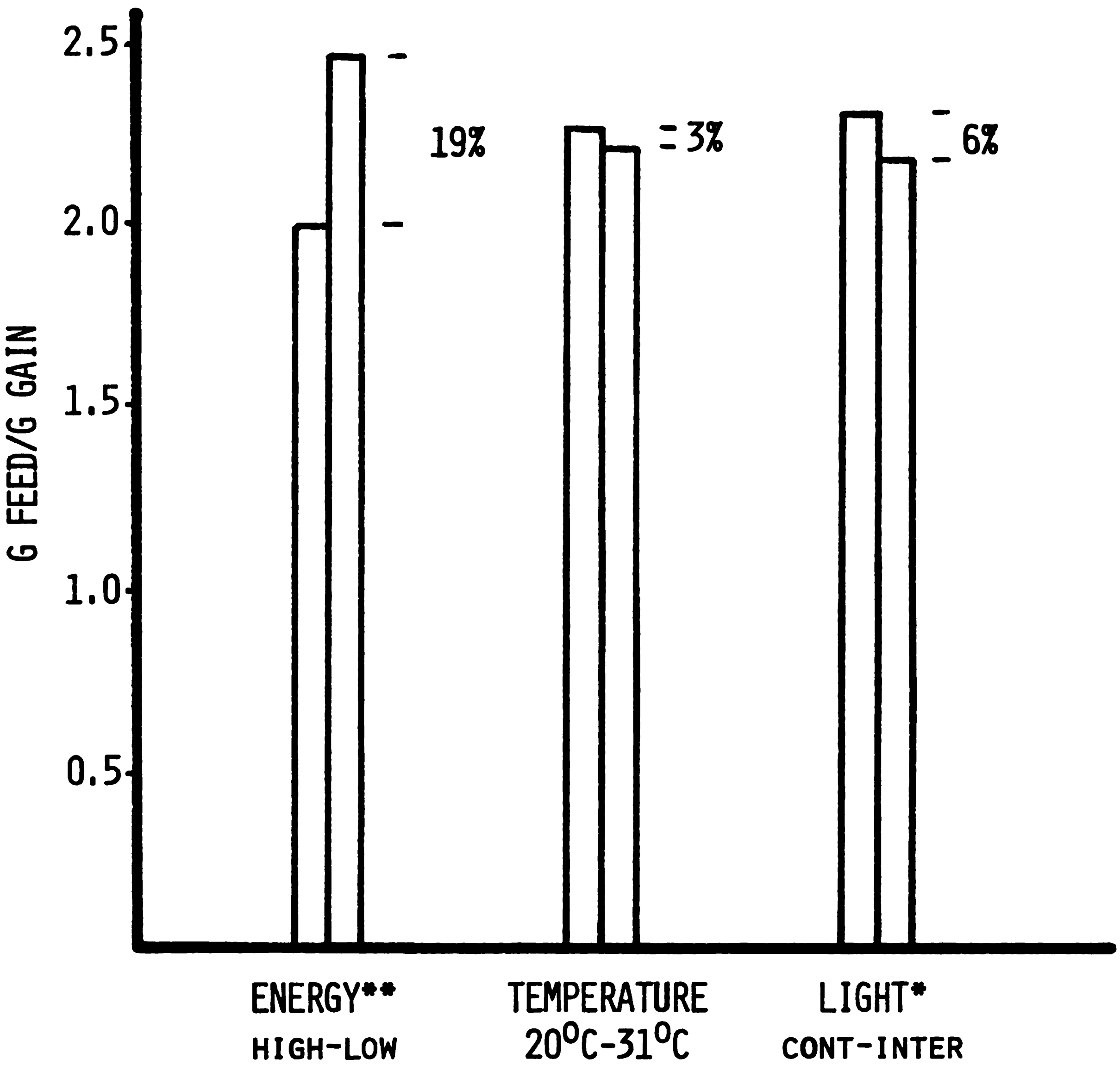
TABLE 15

Feed Efficiency of Birds from 3 to 10 Weeks of Age[1]

Temperature	Treatment	Feed Efficiency gm feed/gm gain
20^0C	LC	2.65[d]
	LI	2.34[bc]
	HC	2.06[ab]
	HI	2.01[a]
31^0C	LC	2.45[cd]
	LI	2.42[cd]
	HC	2.04[a]
	HI	1.90[a]

L = low energy (3080 kcal. M.E./kg)
H = high energy (3410 kcal. M.E./kg)
C = continuous light
I = intermittent light

[1]Means with different postscripts differ significantly ($P < .05$)



CONT = CONTINUOUS
INTER = INTERMITTENT
SIGNIFICANCE:
*$P \leq 0.01$
**$P \leq 0.05$

FIGURE VI

FEED EFFICIENCY IN GRAMS FEED/GRAMS WEIGHT GAIN FOR BIRDS FROM 3 TO 10 WEEKS OF AGE.

TABLE 16

Analysis of Variance of Feed Efficiency in Birds
from 3 to 10 Weeks of Age

Source of Variance	Sum of Squares	Degree of Freedom	Mean Square	F Value
Energy	.86	1	.86	91.66**
Light	.07	1	.07	7.33*
Temperature	.02	1	.02	1.77
Energy & Light	.01	1	.01	.61
Energy & Temperature	.00	1	.00	.00
Light & Temperature	.01	1	.01	1.07
Energy & Light & Temperature	.04	1	.04	3.72
Error	.08	8	.01	
TOTAL	1.07	15		

Significance:

*P < .05
**P < .01

effect on feed efficiency of $P \leq .01$ and $P \leq .05$, respectively. Normal and high temperature had no significant effect on feed efficiency.

The improved feed efficiency with increased dietary energy seems to be a consistent finding among researchers. Deaton *et al.* (1973) found that the amount of feed required per unit of gain increased as dietary energy decreased. When Aitken *et al.* (1954) added 10% fat to the diet of birds from 0 to 10 weeks of age, the efficiency increased by 8%. Waldroup *et al.* (1976) used energy levels identical to those in this study. Using their data it was found that birds from 0 to 8 weeks of age receiving the high energy diet had a 9% increase in feed efficiency when compared to the low energy diet. This was significant to the 95% confidence level. Our results showed a much greater feed efficiency with a high energy diet than that found in the literature. This may be because the experimental period in this study did not include the period of 0 to 3 weeks of age, while the data in the literature included this period.

Huston and Edwards (1961) reported that less feed was required per unit weight gain at the high environmental temperature of 31^0C. A significantly better feed efficiency in birds from 3 to 8 weeks of age was found by Harris *et al.* (1975) as the temperature was increased from 26.7^0C to 35^0C. deAndrade *et al.* (1976) found that feed conversion was improved with high temperature and that the best conversion was noted in the 31^0C environment. These results are similar to our findings in birds from 3 to 8 weeks of age.

Birds from 0 to 8 weeks of age raised in intermittent light were found to have a 9% better feed efficiency by Buckland *et al.* (1973) compared to those receiving continuous light. Proudfoot (1975) also reported that intermittent light treatment resulted in better feed conversion than continuous light treatment. He suggested that the larger rest period afforded by an intermittent light treatment may have contributed to this improvement in feed conversion. Cherry and Barwick (1962) did not find a significant effect of lighting patterns on feed efficiency. In our study, intermittent light improved feed efficiency in birds from 3 to 8 and 3 to 10 weeks of age.

Mortality

The percent mortality was calculated from the number of birds that died during the 3 to 10 weeks of age trial period. Data on the percent mortality of birds for the 3 to 10 weeks with varied light, temperature, and diet are shown in Table 17.

The percent mortality for birds fed low energy diets (3080 kcal. M.E./kg) and raised under high temperature (31^0C) was increased compared to low environmental temperature (20^0C) and high energy diet (3410 kcal. M.E./kg) birds. The lighting scheme, either continuous or intermittent, had absolutely no effect on the mortality. The normal and high environmental temperatures had no significant ($P > .05$) effect on mortality. There appears to be an increase in mortality at high temperature and low energy diet versus normal temperatures and low energy diet. This difference of 2 dead birds at normal temperatures compared to 6 dead birds at high temperatures was not statistically significant ($P > .05$). The mortality of birds raised on a high energy diet was significantly greater ($P < .05$) than those on a low energy diet. Even though there was greater mortality for birds fed the high fat diet, their mortality was still only 11%.

TABLE 17

Mortality during the Experimental Period
(3 to 10 Weeks of Age)

Treatment	Number of Dead Birds Energy Levels (kcal. M.E./kg)* 3410	 3080
NC	4	1
NI	5	1
HC	5	3
HI	4	3
TOTAL	18	8

NC = normal temperature and continuous light
NI = normal temperature and intermittent light
HC = high temperature and continuous light
HI = high temperature and intermittent light

*One hundred sixty birds started at each treatment level

An increase in mortality with high fat diet was described by Jackson *et al.* (1969), who noted that, in two experiments, there was a very high mortality rate (average 41%) of birds fed a diet that contained 28.5% fat (3980 kcal. M.E./kg). This was in comparison to mortality rates of 1% to 16% with birds on lower fat diets (1900 to 3060 kcal. M.E./kg). These results were in contrast to those of Reiser and Pearson (1949), who used lard and hydrogenated vegetable oils in bird starter rations and reported that addition of these fats produced no deleterious effects on the birds. The exact cause of the higher mortality of the birds fed the high energy diet is not known. The major cause of death in all groups of birds was diagnosed as leg abnormality by the M.S.U. Animal Health Diagnostic Laboratory. These results were similar to those reported by Scott (1978) on tibial dyschrondroplasia. Tibial dyschrondroplasia is most severe in rapidly growing broilers being raised under hot weather conditions and is not prevented by any of the known nutrients.

These observations agree with our findings. First, our highest mortality rate was for birds receiving a high energy diet. This was also the most rapidly growing group. Second, the addition of more vitamin premix to the feed did not prevent the occurrence of the leg abnormalities. Although the real cause of the leg abnormalities is not clear, these abnormalities may be the result of genetic factors enhanced by the high stress environment.

SUMMARY

An experiment was conducted to evaluate the effects of the addition of fat in broiler chicken's diet in different environmental conditions and comparisons were made between low energy diet (low fat) and high energy diet (high fat). Test diets were also fed under different environmental temperature and light regimes as a basis for evaluating the comparative practical use of these two diets for birds. Body weight, feed consumption and feed efficiency were used as the criteria for making the comparisons.

Commercial broiler type chickens were selected according to weight at three weeks of age. The selected birds were randomized into treatment groups with two replications per treatment. Each of the two replications had twenty birds (ten of each sex). The total number of birds in the experiment was 320. The growth trial lasted for 10 weeks. Both diets were formulated to be isonitrogenous, but with one diet containing more added fat.

Birds which were fed the high energy diet performed significantly better than those fed the low energy diet to 10 weeks of age under all environmental conditions; at which time the differences in average body weight gain, feed consumption and feed efficiency were significant at $P \leq 0.01$. There was no significant difference in the body weight gain of birds from 3 to 10 weeks of age raised in continuous or intermittent light. Feed efficiency was significantly improved in chickens raised in intermittent light ($P < .01$ for birds from 3 to 8 weeks of age and $P < .05$ for birds from 3 to 10 weeks of age).

The mortality of birds raised on a high energy diet was significantly greater ($P < .05$) than those on a low energy diet. Although there was a greater mortality for chicks fed the high fat diet, their mortality was still only 11%.

APPENDIX

RANCIDITY TEST

Introduction

It is well known that poultry and other animals may suffer harmful effects from rancid fats in feed. Rancid fats tend to destroy carotene, Vitamin A, and other fat-soluble and water-soluble vitamins in feed as well as having direct toxic effects on the animal. Since fat rancidity is deleterious to poultry it should be kept to a minimum.

Literature Review

Fats and oils which have developed an objectionable odor and taste upon storage are said to be rancid. Rancidity is usually the result of chemical changes brought about by oxidation or hydrolysis. Hydrolytic rancidity is caused by simple hydrolysis of fat or oil into fatty acids, diglycerides, monoglycerides and glycerols by microorganisms. However, it has been shown that hydrolytic rancidity does not interfere with the nutritional value of the diet or the fat. Oxidative or peroxidation rancidity, which affects the unsaturated fats or oils, can lead to tremendous loss of their dietary energy value (Privett, 1959). Oxidative rancidity is enhanced by light, heat and the presence of some minerals such as copper, zinc, etc. which act as catalysts.

Many essential dietary components are highly susceptible to oxidation. Oxidized feeds may have substandard nutritional value, which results in low feed efficiency and less monetary return to the producer. Dugan (1961) reported that oxidative rancidity in food has been traced to the lipid portions, in which both the simple triglycerides and the more complex phospholipids and lipoproteins may be involved. Scott *et al.* (1976) reported that there are many factors other than the fatty acid composition of the fat which influence the oxidation process of fat in poultry diets. These include moisture, enzyme activity, pigment, nature of protein, acidity, nature of carbohydrate and trace minerals. Kraybill and Dugan (1954) mention that rancidity is not confined to food of high fat content. It may occur in cereals and other foods of relatively low fat content. Dugan (1961) reported that low temperature storage protects against or reduces the rate of oxidation.

Materials and Methods

At the start of this experiment two samples of each diet were stored in a paper bag for subsequent peroxide level determination. The samples were divided into two parts, each weighing approximately 500 grams. One portion was kept at 27^{0}C and the other at 38^{0}C. The samples were stored in two incubators to maintain these temperatures for the twenty-eight day holding period. All samples were treated similarly and after the twenty-eight day incubation were sent to the laboratory for testing.

Results and Discussion

Samples of the chicken's feed at the beginning of the experimental period were used to study the development of rancidity at high temperatures. The results obtained are shown in Table 18.

The peroxide level varied with the amount of fat in the diet and the storage temperature. The results for the samples stored through 28 days indicated that the peroxide level (rancidity) increased as the fat in the diet and/or storage temperature increased. The peroxide

TABLE 18

Peroxide level of feed kept at high temperature for 28 days.

	Peroxide Level[a]	
Temperature	Low Fat[b]	High Fat[c]
27°C	33.7	35.0
38°C	63.7	69.6

[a]M.E./kg peroxide values above 10 indicate rancidity.
[b]3080 kcal. M.E./kg.
[c]3410 kcal. M.E./kg.

level (rancidity) appeared to be higher at 38^{0}C than at 27^{0}C. A higher storage temperature resulted in higher peroxide level in those samples which contained a greater amount of fat. This demonstrates the effect of storage temperature on fat oxidation. The fact that the low fat feed became very rancid, agrees with the findings of Kraybill and Dugan (1954), who indicated that rancidity is not confined to food of high fat content.

The results of this study indicated that the storage of chicken feed under high temperature greatly increases the rancidity of fat. Since rancidity indicates deterioration and loss of the nutritional value of the feed, storage of feed at high temperatures should be avoided.

Conclusion

The rancidity of high and low energy feed increased greatly when stored at 38^{0}C versus that stored at 27^{0}C for 28 days.

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LITERATURE CITED

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