Effects of Supplementation of Palm Oil in Isonitrogenous Diets on Broilers

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Abstract

Day-old commercial broiler chicks were fed with a commercial diet until three weeks. Then the chicks were randomly distributed by sex in groups of six into 40 wire floor pens, 20 each for male and female. Each pen constituted one of the four replications of factorial design in Completely Randomized Design (CRD). Five experimental diets, including a basal diet were formulated to study the effects of four levels of palm oil (2, 4, 6 and 8%) on growth and body composition.

Increasing palm oil level resulted in a corresponding rise in the dietary energy concentration. It was found that broilers fed on higher energy diets had improved feed and energy consumption, daily weight gain and feed conversion ratio. Total carcass fat content was found to increase while carcass protein decreased at higher levels of palm oil inclusion.

1. Introduction

The broiler industry in the tropics is rapidly expanding and is relatively efficient. However, the full genetic potential of the broilers is seldom achieved due to adverse climatic conditions. The high environmental temperature may reduce production efficiency and retard growth. Under such circumstances, profitability of broiler production is reduced.

The effects of climatic stress on broiler growth has, to a certain extent, been overcome by feeding a high energy diet. It is not very clear how a high energy diet brings about this change. In order to formulate high energy poultry rations for broilers, fat or oil of animal or plant origin is added since ordinary feedstuffs cannot furnish sufficient energy to the required level.

The fats usually used in poultry feeds are tallow and vegetable oils such as soybean oil, rapeseed oil, coconut oil or corn oil, depending on the cost and location where these oils are available.

The southern part of Thailand produces a large amount of palm oil. Palm oil is relatively cheap compared to imported fats and it possesses many good qualities such as a high level of saturated fatty acids as well as vitamin E (antioxidant agent), which make it more stable.

The addition of fat or oil to grower diets can improve efficiency and increases digestibility in both broilers and pigs. For laying hens, the addition of some fat in the diet increases egg production and improves feed efficiency.

Although much work has been done on the utilization of animal and vegetable fats, reports on the use of palm oil in poultry feeds are limited.

Very little information is available on the use of palm oil as a source of energy for improving growth perfomance and carcass composition, especially under the warm climatic conditions. The objective of this study was to evaluate the effects of palm oil supplementation to provide different energy levels in isonitrogenous diets on growth and carcass composition of broilers.

2.Materials and methods

Animals and diets

One hundred and twenty males and an equal number of female day-old commercial broiler chicks were fed with a commercial diet containing metabolizable energy, ME, of 3100 kcal/kg and 23% crude protein. A 100-W incandescent light bulb provided continuous lighting during brooding. Feed and water were allowed *ad libitum.*

At three weeks of age the chicks were randomly distributed by sex in groups of six birds per replicate into 40 wire floor pens with natural ventilation. Five experimental diets, including a basal diet were formulated to study the effects of four levels of crude palm oil (2, 4, 6 and 8%) on growth, body composition and energy utilisation. The diets were isonitrogenous and the composition of the experimental diets are given in the table 1. Ethoxyquin was added as an antioxidant to all the feed. The levels of nutrients with the exception of ME content, in the diets with 0, 2, 4, 6 and 8% palm oil exceed the National Research Council (NRC) 1984 recommendations[1]. The ME content for diets with 0, 2, 4, 6 and 8% palm oil inculsion was 3106, 3265, 3564 and 3675 ME kcal/kg respectively. Since the crude protein was maintained at 20% for all the diets, the C:P rations increased with the addition of palm oil (Table 1).

The ambient temperature was not controlled and fluctuated from 23°C to 36°C during the experiment which is considered normal daily temperature in the tropical climate. The diets were fed *ad libitum* in mash form for a further period of four weeks. Feed was added in small portions (about 100 g/bird) twice daily to the troughs to avoid excessive accumulation and under oxidation and wastage.

Body weight and feed consupmtion data were collected once a week, on a group basis. At the termination of the experiment on day 49, the final weights of the chicks were determined. For carcass analysis, the chickens were fasted for 48 h in order to reduce the effect of gut content on body weight. From each replicate, two birds of each sex were selected at random and individually weighed. The chicks were sacrificed without blood loss by an overdose intravenous injection of anesthesia (Nembutal). Each carcass was again weighed, placed in individual plastic bags and stored in a freezer for at least 48 h before analysis.

Determination of metabolisable Energy (ME)

The ME was determined for all the diets using the rapid technique developed by Farrell [2] and Vohra et al. [3].

The ME was calculated using the formula developed by Brue and Latshaw [4] as follows:

$$ME = \frac{(A)(B)-(C)(D)}{A}$$

where,

ME = Metabolisable energy (kcal/kg feed)
A = Feed consumed(kg)
B = Gross energy of feed (dcal/kg feed)
C = Excreta voided(kg)
D = Gross energy of excreta(kcal/kg exereta)

Carcass analysis

Preparation of dry homogenates from whole and eviscerated chicks were done before analysis using the technique developed by Sibbald and Fortin [5].

Proximate analysis

Dry homogenates were allowed to equilibrate with atmospheric moistue prior to analysis and air-dry weights were measured. Because the analyses were spread over time, it was necessary to correct the moisture gain in accordance with the AOAC method [6].

Statistical analysis

The data were statistically analyzed by both regression analysis and analysis of variance using the Statistical Analysis System (SAS) [7]. The differences between treatments were determined using the protected Least Significant Difference (LSD) method [8]. Simple correlations were determined for all possible pairs of variables.

3. Results

Feed intake

The data on feed intake are presented in Tables 2 and 3. The amount of feed consumed varied from 93.93 g/d for birds on 6% oil to 97.86 g/d for birds on 8% oil. The observed differences among treatments were not significant (Table 2). There was a trend for increased feed intake with increasing oil content in the diets (r=0.39) with the exception of birds on 6% oil, which had the lowest feed intake. However, males consumed a significantly

Table 1. Composition of experimental diets

	Levels of palm oil %				
	0	2	4	6	8
Fish meal	12.00	12.00	12.00	12.00	12.00
Corn meal	70.50	68.50	66.50	64.00	61.50
Soybean meal	15.00	15.40	15.80	16.30	16.80
Palm oil	-	2.00	4.00	6.00	8.00
Dicalcium phoshate	0.05	0.03	0.03	0.021	0.016
Lime stone	0.25	0.26	0.27	0.282	0.30
Choline chloride	0.35	0.35	0.35	0.35	0.35
Salt	0.50	0.50	0.50	0.50	0.50
Premix	0.25	0.25	0.25	0.25	0.25
Coccidiostat	0.10	0.10	0.10	0.10	0.10
Kaolin Clay	1.00	0.61	0.20	0.197	0.184
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Protein (%)	20.004	20.004	20.004	20.004	20.004
ME (kcal/kg)	3035.00	3143.00	3250.00	3344.00	3437.00
Ether extract (%)	3.93	5.85	7.78	9.77	11.60
Calcium (%)	0.90	0.90	0.90	0.90	0.90
Avaible phosphorus (%)	0.40	0.40	0.40	0.40	0.40
Lysin (%)	1.18	1.19	1.20	1.21	1.22
Methionine + Cystine (%)	0.73	0.73	0.73	0.72	0.72
Methionine (%)	0.45	0.45	0.45	0.45	0.45
Determined analysis					
Protein (%)	19.73	20.58	20.50	20.13	19.86
ME (kcal/kg)	3106	3265	3434	3564	3675
Ether extract (%)	3.85	5.68	7.62	9.54	11.32
Calorie:Protein ratio (C:P ratio)	157	159	168	177	185

(Ethoxyquin was added at 125 mg/kg feed as antioxidant)

Table 2. Effects of palm oil levels on performance of broilers[1]

	Levels of palm oil %				
	0	2	4	6	8
Feed intake (g/bird.day)	$95.00^{a}\pm2.94$	$95.71^{a}\pm3.53$	$96.79^{a}\pm4.20$	$93.93^{a}\pm3.52$	$97.86^{a}\pm3.23$
Weight gain (g/bird.day)	$43.93^{a}\pm1.53$	$43.57^{a}\pm1.79$	$46.07^{ab}\pm2.62$	$46.07^{ab}\pm2.15$	$48.21^{b}\pm1.74$
Feed/gain	$2.16^{ab}\pm0.03$	$2.21^{b}\pm0.07$	$2.10^{ab}\pm0.04$	$2.05^{a}\pm0.04$	$2.04^{a}\pm0.02$
Nitrogen intake (g/bird.day)	$2.68^{a}\pm0.08$	$2.86^{a}\pm0.11$	$2.85^{a}\pm0.13$	$2.71^{a}\pm0.10$	$2.75^{a}\pm0.09$
Energy intake (kcal/bird.day)	$263.87^{a}\pm8.16$	$279.42^{b}\pm10.28$	$298.48^{bc}\pm12.98$	$300.24^{c}\pm11.21$	$320.91^{d}\pm10.68$

[1]Mean of four replicate determinations on 3 chicks+standard error of mean.
Different superscripts in the same row show significant differences at the 5% level.

(P<0.01) higher amount of feed than females (Table 3).

Weight gain

The body weight of the chickens for the various treatments is shown in Table 4. From the results birds fed on 8% palm oil had the highest body weight compared to the control. The results also showed that the males had higher body weight than females.

The data on body weight gain are presented in Tables 2 and 3. The diet with 2% palm oil did not exert any effect on body weight compared to the control. Chicks on both these diets had almost similar weight gain at about 43 g/d. Chicks given 4, 6 and 8% palm oil diets gained 46.07, 46.07 and 48.21 g/d, respectively, and were significantly different (P<0.05) to the control and 2% palm oil diet. The body weight appeared to increase at higher levels of palm oil inclusion in the diets. However, there was no significant change in body weight between 4, 6 and 8% palm oil levels.

Males were found to weigh significantly more than females (P<0.01), (Table3).

Feed to gain ratio

Feed conversion appeared to improve with increasing palm oil content of diets (Table 2). It varied from 2.04 for birds on 8% palm oil to 2.21 for birds on 2% palm oil. Birds on 8% palm oil had the highest feed effciency but were not significantly different from 6% oil level. The differences observed between the control, 2 and 4% palm oil diets were also not significant. Males were found to have a better feed conversion (2.07) than females (2.14) (Table 3).

Nitrogen intake

The data on nitrogen intake is presented in Tables 2 and 3. Chicks on the control diet had the lowest nitrogen consumption (2.68 g/d). The nitrogen intake in the treatment groups was generally higher. The amount of nitrogen consumed for 2, 4, 6 and 8% palm oil diet was found to be 2.68, 2.85, 2.71, and 2.75 g/d respectively. The differences were neither significant, between treatments, nor with the control.

The nitrogen intake by males at 3.01 g/d was significantly (P<0.01) higher than 2.53 g/d consumed by females (Table 3).

Energy intake

The energy consumption data are also presented in Tables 2 and 3. There was a trend of increased energy intake with increasing palm oil content of diets. The relationship appears to be linearly related with an r value of 0.98. The birds on the control diet had the lowest energy intake (263.87 ME kcal/d), while those on the 8% oil diet consumed the highest amount. The increase in energy consumption in all the treated groups was significantly different to the control (P<0.05). There was no significant difference between 2 and 4% or between 4 and 6% oil levels. The energy intake on the 8% oil diet was the highest and was significantly different (P<0.05) to all other groups. Males were found to consume 317 ME kcal/d compared to 267 ME kcal/d in females. The difference is significant at P<0.01 (Table 3).

Body composition

Ash

The data on ash content are shown in Tables 5 and 6. There was a trend for ash to decrease at higher levels of palm oil inclusion in the diets. The diet with 2% palm oil did not exert any effect on body ash compared to the control. Chicks on both these diets had almost similar levels of ash at about 8%. There was a reduction of ash content at higher levels of palm oil in the diets. Chicks given 4, 6 and 8% palm oil diets had 7.43, 7.25 and 7.46% of ash, repectively, but the differences between them were not significant. When compared to the control and 2% palm oil diets, chicks on higher oil diets had signigicantly lower body ash content (P<0.05). The ash content in carcass of males and females (Table6) was not significantly different.

Protein

The crude protein content of the carcass is presented in Tables 5 and 6. There was a trend for protein content to decrease with increasing palm oil content in the diets (Table 5.) The relationship appeared to be inversely related with an r value of -0.96. The birds on the

Table 3. Performance of male and female broilers[1]

	Male	Female
Feed intake (g/bird.day)	104.00^a±1.23	87.71^b±0.8
Weigh gain (g/bird.day)	50.14^a±0.83	41.00^b±0.57
Feed/gain	2.07^a±0.03	2.14^a±0.03
Nitrogen intake(g/bird.day)	3.01^a±0.04	2.53^b±0.03
Energy intake(kcal/bird.day)	317.52^a±6.25	267.65^b±4.57

[1]See Table 2.
Different superscripts in the same row show significant difference at the 1% level.

Table 4. Effects of palm oil levels on body weight (kg/bird)

Age(Week)	Palm oil levels									
	0		2		4		6		8	
	M	F	M	F	M	F	M	F	M	F
3	0.60	0.53	0.59	0.53	0.58	0.53	0.62	0.53	0.60	0.55
4	0.95	0.83	0.93	0.82	0.96	0.81	0.96	0.79	0.96	0.86
5	1.30	1.13	1.27	1.12	1.30	1.11	1.31	1.09	1.33	1.16
6	1.65	1.43	1.67	1.42	1.72	1.41	1.73	1.42	1.76	1.52
7	1.94	1.66	1.90	1.66	2.06	1.64	2.05	1.67	2.07	1.78

(M = Male; F = Female)

Table 5. Effects of palm oil levels on the body composition of broilers[1]

	Levels of palm oil %				
	0	2	4	6	8
Dry matter (%)	97.80^a±0.39	97.41^a±0.29	97.85^a±0.24	97.18^a±0.57	97.39^a±0.38
Ash (%)	8.16^a ±0.23	8.06^a ±0.25	7.43^b ±0.16	7.25^b ±0.20	7.46^b±0.10
Protein (%)	52.62^a±1.04	49.21^b ±1.11	46.46^{bd}±0.64	45.61^{cd} ±0.62	45.23^{cd}±0.57
Fat (%)	32.03^a±1.13	35.43^b ±1.16	38.04^{bc} ±0.79	38.28^c ±1.26	37.69^{bc}±1.00

[1] Mean of four replicate determinations on 2 chicks ± standard error of mean
Figures with different superscripts in the same row differ significantly at the 5% level

Table 6. Effect of sex on the body composition of broilers[1]

	Male	Female
Ash (%)	7.84^a±0.12	7.51^a±0.16
Protein (%)	48.38^a±0.82	47.28^a±0.79
Fat (%)	34.84^a±0.81	37.75^b±0.76

[1]See Table 5.
Figures with different superscripts in the same row differ significantly at the 1% level.

control diet had the highest protein content (52.62%), while those on the 8% oil diet had the lowest. The decrease in the crude protein level in all the treated groups was significantly different to the control

(P < 0.05). There was no significant difference between 2 and 4% or among 4, 6 and 8% oil levels. The crude protein of chicks on the control diet was the highest and differed significantly (P<0.05) from all other treatment groups. However, the crude protein levels of males and females (48.38 and 47.28% respectively) were found to be almost similar. The small difference was not significant.

Fat

The effects of plam oil supplementation on fat content in the carcass are shown in Tables 5 and 6. There was a trend for increased fat at higher levels of palm oil inclusion in the diets. The relationship appeared to be linear with an r value of 0.89. The chicks on the control diet had the lowest percentage of fat (32.03%), while those on 6% oil diet had the highest. The increase in fat in all the treated groups was significantly different to the control (P<0.05). There was difference among the 4, 6 and 8% palm oil diets, although the fat content of chickens on 6% palm oil was comparatively higher than 4 and 8% palm oil. However, the fat content in males at 34.84 % was significantly (P<0.01) lower than the 37.75% in females (Table 6).

4. Discussion

The effects of varying ME and palm oil level in isonitrogenous diets on voluntary intake, growth and body composition of chicks were studied. Feed intake appeared to be constant regardless of treatment. However, birds fed 2, 4 and 8% palm oil diets consumed more feed than the control with the exception of chicks on 6% palm oil. These observed differences were not significant. On the other hand, ME consumption was significantly higher in the treated groups compared to the control. The relationship between ME intake and dietary energy level appeared to be linearly related (r=0.98). The results clearly indicate the benefit of high energy diets since they can increase the level of ME consumption. It is possible that the heat increment has been correspondingly reduced with increasing level of palm oil in the diets, thus enabling the chicks to increase voluntary intake. Similar effects were also observed by Fuller and Mora [9] and Lipstein and Bornstein [10].

There was a tendency for body weight of the chicks to increase with increasing palm oil content in the diets. Statistical analysis, however, failed to show signigicant difference between the control, 2, 4 and 6% or between 6 and 8% palm oil diets. Only chicks fed 8% palm oil gained significantly more than the control. However, the relationship appeared to be linear except that chicks on 4 and 6% palm oil diets had similar growth rate at 46.07 g/d. The increase in body weight is mostly due to higher ME consumption in the palm oil supplemented groups. It seems possible to improve growth rate of chicks reared under tropical conditions with fluctuating (23-36^{o}C) ambient temperature by incoporation palm oil in the diets to increase the ME density. In fluctuating temperature conditions heat stress is most severe during the day. To some extent, heat stress could be reduced with the addition of palm oil in the diets due to the lowering of heat increment as demonstrated by Dale and Fuller [11,12] and Bartov et al. [13].

The effect of sex on body weight is more pronounced. The growth rate of male chicks (50.14 g/d) was singificantly more than of females (41.00 g/d) (Table 3). This is probably due to the male consuming more feed than the female resulting in concomitant increase in ME consumption. Conversely, the males had less carcass fat than the females (Table 6). These differences in the results demonstrated the physiological and genetical variability between sexes. The male is known to grow faster than the female and at the same time had higher metabolic rate [14]. Besides, the circulation level of growth hormone which is positively connected with growth rate is higher in male chicks [15]

Feed conversion appeared to improve with increasing ME intake. The highest feed conversion value of 2.04 was obtained from 8% palm oil, but it was not singificantly higher compared to the group on 6%. The differences obtained between the control, 2 and 4% groups were also not significant (Table 2). As stated earlier, feed intake was about the same inspite of varying ME content. Increasing ME density resulted in higher ME consumption. Higher ME intake caused an improvement in both average daily gain and feed coversion ratio (Table 2). Broilers that consumed more nutrients per day required less days to reach a given weight which explained the differences in the results between the control and the treated groups. This experiment indicates the advantage of a high energy diet in feeding broilers under tropical conditions.

The effects of increasing ME density in the diets by adding palm oil resulted in a change in body compositon (Table 5). The percentage of carcass ash was reduced when palm oil level exceeded 4%. At higher level (6 and 8%) of palm oil inclusion, ash content was further reduced. These results are in agreement with those of Pepper et al. [16], Griffith et al. [17], Waibel and Mraz [18] and Whitehead et al. [19]. The addition of oil or fat in the feed might interfere with mineral metabolism and thus causing a lowering in the body ash content as similarly shown by Hakanssan [20, 21].

Crude fat in the carcass dry matter was found to increase with increasing palm oil content of the diets (Table 5). The relationship appeared to be linear with the value of 0.89. The chicks fed 2, 4, 6 and 8% diets had significantly higher carcass fat content than the control diet. The increase in fat content indicated that the amount of energy consumed by the chicks was excessive. It was possible that the reasons for the high fat content in the treated groups could be due to the widening of the calorie:protein ratio. Calorie:protein ratio has been shown by Yamashita et al. [22] and Shen et al. [23] to affect body composition, particularly the fat content. They showed that carcass fat was reduced either by: (1) decreasing dietary energy levels while maintaining the protein content or (2) by maintaining the energy level but increasing the protein content.

Furthermore, supplementing palm oil in the diets produced significant changes in carcass crude protein content (Table 5). All the chicks fed 2, 4, 6 and 8% palm oil had significantly lower carcass protein content than the control, the lowest being in chicks given the 8% palm oil diet.

The decline in crude protein and ash is likely due to the substantially higher rate of fat gain during this period. Fat, protein and ash are the basic constituents making up most of the carcass dry matter content. A change in any component could affect the composition of the other.

The rate of fat accumulation was also different between sexes.(Table 6). Male chicks had significantly lower carcass fat than females in spite of the fact that the males consumed more energy than females. This is probably due to the higher metabolic rate in the males. These results are similar to those of Edwards and Denman [24], Dale and Fuller [12], and Mabray and Waldroup [25]. Another factor is probably due to higher estrogen hormone in females, hence it increased the amount of fat deposited in the tissue [26]. However, in terms of carcass protein, the difference between male and female birds was not significant, although the nitrogen intake of the male was significantly higher than the female birds. The ash content in the male and female birds was not significantly different althoung the nitrogen intake of the male was significantly higher than the female birds. This was similar to the findings of Robbins and Ballew [14].

The persent results undicate that the determined ME for diet with 0, 2, 4, 6 and 8% palm oil was 3106, 3265, 3434, 3564 and 3675 ME kcal/kg respectively (Table 1). At 2 and 4% palm oil level, the increase of ME content was higher than at 6 and 8% palm oil level. Hence, the difference in the ME values at increasing levels of fat inclusion is similar to the theory that the response between fat levels and ME is curvlinear.

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