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Effect of Feeding Prilled Palm fat with Lyso-Lecithin on Broiler Growth Performance, Nutrient Digestibility, Lipid Profile, Carcass, and Meat Quality

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Abstract
A feeding trial was carried out to investigate the effects of lecithin on growth performance, nutrient digestibility, lipid profile, carcass characteristics and meat quality of broiler chickens. A total of 240 one-day-old male broiler chicks (Cobb 500) were obtained from a local hatchery and raised for 42 days. The chicks were divided into 5 dietary treatments. The diets supplemented with prilled palm fat + 2% lysolecithin (PFL) replacing palm oil at 0%, 1%, 3%, 5%, and 7%. Each treatment group was divided into 6 replicates and 8 chicks per each replicate. Feed and water were offered *ad libitum* to the birds. The individual body weight and the feed intake for each replicate were recorded. In the finisher and overall periods, the findings showed that body weight gain (BWG) was significantly ($P < 0.05$) higher in birds fed 1% PFL compared to those birds fed 5% or 7% PFL. The nutrient digestibility was significantly ($P < 0.05$) higher in broiler supplemented with 1% PFL compared to the rest of the treatment groups. However, no significant differences were observed against 3% PFL for crude fat digestibility. The breast meat color was within the normal range in broiler fed 1% PFL than those fed higher ratios of PFL. The study revealed that supplementation of PFL at 1% substantially improved nutrient digestibility as well as BWG and FCR during the overall period.

Introduction

The main source of energy in poultry is yellow corn (Alshelmani *et al.,* 2017b). Fully utilizing the feed by adding energy-rich diets such as fat and oil is one of the methods to minimize feed cost (Mieczkowska *et al.,* 2001). Usually, animal fats and vegetable oil are used in poultry feeds. These fats are usually added to the broiler diet to improve productivity (Huang *et al.,* 2007; Abdulla *et al.,* 2019), and improve broiler performance. Palm oil is usually used in diet as a source of fat and energy in Asia, especially in Malaysia which considered one of the major producers of palm oil. However, there are concerns on the feed which are not fully utilized by the poultry, mainly due to deficiency of few enzymes at a younger age. Nevertheless, fat digestion will be developed and improved with their age (Hertrampf, 2001; Cheah *et al.,* 2017). The ability of the chicks to utilize fat is not as efficient as compared with adult birds. Prilled palm fat is commercially produced for ruminants and having high saturated fatty acids. There are some promising reports on pigs fed prilled fat (Grimes *et al.,* 1996). Fat needs to be emulsified before it can be digested more efficiently. Therefore, supplementation of lecithin during the manufacturing of prilled fat may improve the digestibility of the fat. Emulsifiers help to increase the monoacylglycerols in the small intestine. Therefore, it leads to an increase in nutrient absorption (Melegy *et al.,* 2010; Akit *et al.,* 2018). Thus, the study was carried out to

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investigate the effect of prilled palm fat with lysolecithin on the performance, nutrient digestibility, lipid profile, carcass characteristics and meat quality in the broiler.

Materials and methods

Birds and experimental diets

The study was conducted under the guidelines of the Research Policy on Animal Ethics of the Universiti Putra Malaysia. The experimental design was based on a completely randomized design (CRD). A total of 240 male broilers (Cobb 500) one-day-old chicks were obtained from a local commercial hatchery and raised for 42 days. The chicks were weighed and randomly divided into 5 treatment groups. Each treatment group was divided into 6 replicates with 8 chicks for each replicate and allocated in 30 pens. The processing of prilled palm fat + 2% lysolecithin (PFL) was created by heating the palm oil and cooling under pressure to increase the melting point of the fat. At the same time, 2% of lysolecithin was supplemented to improve the digestibility of the prilled fat. Five dietary treatments were formulated in the feed factory at the Poultry Unit, Department of Animal Science, Universiti Putra Malaysia and supplemented with PFL replacing palm oil at 0%, 1%, 3%, 5%, and 7%. The birds were raised in the conventional open-sided house with cyclic temperature (maximum 35ºC and minimum 24ºC) and humidity (maximum 90% and minimum 66%). The birds had access to the feed and drinking water *ad libitum*. The lighting was continued 24 hours per day. The chicks were vaccinated against Newcastle disease (ND) and Infectious Bronchitis (IB) at 4 and 21 days, while on day 7, the chicks were given Infectious Bursal Disease (IBD) vaccine. The birds were fed with starter diets from 0-21 days, and finisher diet from 22-42 days based on NRC, (1994) (Tables 1 and 2).

Table 1. Ingredients and chemical compositions of the starter diet (% as-fed basis)

Ingredients	PFL level (%)				
	0	1	3	5	7
Yellow corn	41.00	41.00	40.50	40.00	39.30
Soybean meal (44% CP)	36.00	36.00	36.00	36.00	36.10
Wheat Pollard	10.00	10.00	10.50	11.00	11.60
Palm oil	7.00	6.00	4.00	2.00	0.00
prilled palm fat + Lysolecithin	0.00	1.00	3.00	5.00	7.00
L- Lysine HCL	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.40	0.40	0.40	0.40	0.40
L-Threonine	0.15	0.15	0.15	0.15	0.15
Di-calcium phosphate (21%)	2.20	2.20	2.20	2.20	2.20
Calcium carbonate	1.90	1.90	1.90	1.90	1.90
Choline Chloride	0.20	0.20	0.20	0.20	0.20
Salt	0.30	0.30	0.30	0.30	0.30
Mineral premix [1]	0.20	0.20	0.20	0.20	0.20
Vitamin premix [2]	0.20	0.20	0.20	0.20	0.20
Antioxidant [3]	0.05	0.05	0.05	0.05	0.05
Toxin binder [4]	0.10	0.10	0.10	0.10	0.10
	Calculated analysis (% dry matter basis) [5]				
ME (Kcal/kg)	3099	3101	3103	3106	3108
Crude protein, %	22.21	22.21	22.25	22.29	22.38
Ether extract, %	8.69	8.71	8.72	8.73	8.73
Calcium (%)	1.50	1.55	1.55	1.55	1.55
Available phosphorus (%)	0.50	0.54	0.54	0.54	0.54
Methionine + Cystine (%)	1.06	1.06	1.06	1.06	1.06
Lysine (%)	1.30	1.40	1.40	1.40	1.40
Threonine (%)	0.79	0.90	0.90	0.90	0.90

ME, metabolizable energy; CP, crude protein; PFL: prilled palm fat + 2% lyso-Lecithin

[1] Provided per kg diet: Fe 100.0 mg; Mn 110.0 mg; Cu 20.0 mg; Zn 100.0 mg; I 2.0 mg; Se 0.20 mg; Co 0.60 mg.

[2] Provided per kg diet: vitamin A 6670 IU; vitamin D3 1000 IU; vitamin E 23 IU; vitamin K3 1.33 mg; cobalamin 0.03 mg; thiamin 0.83 mg; riboflavin 2.0 mg; folic acid 0.33 mg; biotin 0.03 mg; pantothenic acid 3.75 mg; niacin 23.30 mg; pyridoxine 1.33 mg.

[3] Butylated hydroxytoluene.

[4] Toxin binder contains natural hydrated sodium calcium aluminum silicates.

[5] Diets were formulated using FeedLIVE software (FeedLIVE 1.52, Bangkok, Thailand).

Samples and data collection

The body weight (BW) was weighed individually, and feed intake (FI) was recorded weekly for each replicate. The body weight gain (BWG) and feed conversion ratio (FCR) were calculated. Two birds at day 42 from each replicate were taken and slaughtered for the sampling of blood, abdominal fat, and breast. Meat quality was measured from breast meat. Abdominal fat pad and carcass parts were calculated based on live BW. Blood samples were collected from jugular to measure the lipid profile (Alshelmani *et al.,* 2017a). The digesta was collected from the ileum and kept at - 80ºC for nutrient digestibility.

Table 2. Ingredients and chemical compositions of the finisher diet (% as-fed basis)

Ingredients	PFL level (%)				
	0	1	3	5	7
Yellow corn	51.00	51.00	51.00	51.00	50.40
Soybean meal (44% CP)	29.00	29.00	29.00	29.00	28.90
Wheat Pollard	7.40	7.40	7.40	7.40	8.10
Palm oil	7.00	6.00	4.00	2.00	0.00
prilled palm fat + Lyso-Lecithin	0.00	1.00	3.00	5.00	7.00
L- Lysine HCL	0.10	0.10	0.10	0.10	0.10
DL-Methionine	0.30	0.30	0.30	0.30	0.30
L-Threonine	0.15	0.15	0.15	0.15	0.15
Di-calcium phosphate (21%)	2.20	2.20	2.20	2.20	2.20
Calcium carbonate	1.90	1.90	1.90	1.90	1.90
Choline Chloride	0.20	0.20	0.20	0.20	0.20
Salt	0.30	0.30	0.30	0.30	0.30
Mineral premix [1]	0.15	0.15	0.15	0.15	0.15
Vitamin premix [2]	0.15	0.15	0.15	0.15	0.15
Antioxidant [3]	0.05	0.05	0.05	0.05	0.05
Toxin binder [4]	0.10	0.10	0.10	0.10	0.10
Calculated analysis (% dry matter basis) [5]					
ME (Kcal/kg)	3178	3182	3189	3197	3199
Crude protein (%)	19.06	19.06	19.06	19.06	19.08
Ether extract (%)	8.98	9.00	9.02	9.05	9.06
Calcium (%)	1.50	1.50	1.50	1.50	1.50
Available phosphorus (%)	0.50	0.50	0.50	0.50	0.50
Methionine + Cystine (%)	0.89	0.89	0.89	0.89	0.89
Lysine (%)	1.05	1.05	1.05	1.05	1.05
Threonine (%)	0.83	0.83	0.83	0.83	0.83

ME, metabolizable energy; CP, crude protein; PFL: prilled palm fat + 2% lysolecithin.

[1] Provided per kg diet: Fe 100.0 mg; Mn 110.0 mg; Cu 20.0 mg; Zn 100.0 mg; I 2.0 mg; Se 0.20 mg; Co 0.60 mg.

[2] Provided per kg diet: vitamin A 6670 IU; vitamin D_3 1000 IU; vitamin E 23 IU; vitamin K_3 1.33 mg; cobalamin 0.03 mg; thiamin 0.83 mg; riboflavin 2.0 mg; folic acid 0.33 mg; biotin 0.03 mg; pantothenic acid 3.75 mg; niacin 23.30 mg; pyridoxine 1.33 mg.

[3] Butylated hydroxytoluene.

[4] Toxin binder contains natural hydrated sodium calcium aluminum silicates.

[5] Diets were formulated using FeedLIVE software (FeedLIVE 1.52, Bangkok, Thailand).

Nutrient digestibility

Titanium dioxide (TiO_2) was added to the feed, four days before slaughtering, as an indigestible marker at 0.3% as mentioned by Alshelmani *et al.,* (2016). The TiO_2 was determined based on the method described by Short *et al.,* (1996). Proximate analysis was applied to the feed and digesta to calculate the dry matter (DM), organic matter (OM), crude protein (CP), and ether extract (EE) digestibilities based on the method of AOAC (1995).

Apparent ileal digestibility (AID) of the nutrients was calculated based on nutrients and TiO_2 concentration of the diets and ileal digesta using the following formula (Son *et al.,* 2014):

$$AID = 100 - [100x\ (\%\ TiO_2 \text{ in feed}/\ \%\ TiO_2 \text{ in digesta})\ x\ (\% \text{ nutrient in digesta}/\ \% \text{ nutrient in feed})]$$

Carcass characteristics

At the end of the trial, two birds were slaughtered from each replicate (pen). All the carcass parts were expressed as a percentage of the live BW as described by Alshelmani *et al.,* (2017a)

Measurement of meat quality

Measurement of breast pH, meat color, drip loss, cooking loss, and tenderness was measured based on the methods described by Alshelmani *et al.,* (2017a).

Serum lipid profile

At day 42, blood samples were collected from 12 birds for each treatment and placed in vacutainer tubes to collect the serum. Total cholesterol, triacylglycerol (TAG), low-density lipoprotein (LDL) and high-density lipoprotein (HDL) were analyzed using test kits (Roche Diagnostics, Basel, Switzerland).

Statistical analysis

Data were analyzed using the General Linear Model procedure of the statistical analysis system (SAS, 2003). The experimental design was a completely randomized design (CRD). Tukey's test was used to compare the means of treatment at probability 5%; ($P < 0.05$). The statistical model used for the trial was $Y_{ij} = \mu + T_i + E_{ij}$, where, Y_{ij} = response variables; μ = the overall mean; T_i = the effect of dietary treatment; E_{ij} = the experimental error.

Results and discussion

Growth performance

The effects of feeding different levels of PFL on BWG, FI, and FCR in broiler chickens are shown in Table 3. There were no significant differences ($P > 0.05$) among the dietary treatments in growth performance during the starter phase. In the finisher phase, The BWG was significantly higher ($P < 0.05$) in the broiler chickens fed the diet supplemented with 1% PFL compared to those birds fed 0%, 5% or 7% PFL. The BWG was higher but not significantly in the group of chickens fed 1% PFL compared to that group fed 3% PFL. No significant differences ($P > 0.05$) were shown among the treatments in terms of FI and FCR.

Regarding the overall growth performance, the BWG was significantly ($P < 0.05$) increased in broiler chickens fed the diet supplemented with 1% PFL compared to those birds fed 5% or 7% PFL. The lowest FI was observed for those birds fed 5% and 7% PFL, respectively. The FI was significantly ($P < 0.05$) lower in broiler fed 5% PFL compared to the control group (0% PFL). It was also observed that FCR was significantly ($P < 0.05$) decreased in those birds fed 5% PFL compared to those chickens fed 0% or 3% PFL.

The BWG in the current study agreed with Awad *et al.,* (2014), who mentioned that BWG was 778 g at 21 days old for broiler (Cobb × Cobb) fed 20.7% CP and 3020 Kcal/kg under the tropical conditions. The reduction in FI for those groups of chickens fed diets supplemented with 3%, 5%, and 7% PFL could be attributed to the physical appearance of the feed which associated with decreasing the levels of palm oil. Therefore, the diet became drier, dustier and undesirable to the chickens. The findings are consistent with Cox *et al.,* (2000), who reported that a significant reduction of feed consumption was observed when birds supplemented with lecithin. Another point to consider is that feeding 1% PFL improved the BWG compared to the rest of dietary treatments during the finisher or overall performance. The FI was higher ($P > 0.05$) for birds fed 1% PFL compared with the other groups. The results are in agreement with Roy *et al.,* (2010), who indicated that supplementation of 1% emulsifier in broiler chickens exhibited growth improvement compared with those groups of chickens supplemented with 0% or 2%. The reduction in BWG in the present study could be due to the increase of saturated fatty acids to unsaturated fatty acids ratio as the PFL increased in broiler diets (groups fed 5% or 7% PFL). The findings are corroborated with Jansen *et al.,* (2015), who mentioned that broiler performance was decreased for birds fed diets supplemented with pig lard compared to that group fed with soybean oil. Also, they found that lysolecithin supplementation showed improvement in chickens fed with pig lard. However, a slight improvement occurred for those groups of chickens fed with soybean oil (Jansen *et al.,* 2015).

Table 3. Effect of feeding different levels of PFL on body weight gain (g/ bird), feed intake (g/ bird) and feed conversion ratio (g feed/ g gain) in broiler chickens

Parameter	Dietary treatment (PFL%)					*SEM*[1]	*P-value*
	0	1	3	5	7		
0–21 days							
Initial body weight [2]	39.72	39.84	40.52	39.46	40.28	0.42	0.372
Body weight gain [2]	719.80	749.20	667.33	701.16	653.67	30.48	0.243
Feed intake	1076.99	1020.29	1026.55	969.27	1001.78	23.98	0.054
FCR	1.50	1.51	1.55	1.59	1.53	0.03	0.222
22–42 days							
Body weight gain	1612.81[b]	1771.80[a]	1703.33[ab]	1605.66[b]	1625.04[b]	24.62	<0.0001
Feed intake	2982.04	2996.52	2943.78	2619.25	2735.89	98.13	0.056
FCR (g Feed/g Gain)	1.85	1.69	1.73	1.63	1.69	0.06	0.144
Overall (0-42 days)							
Body weight gain	2295.14[ab]	2425.07[a]	2373.95[ab]	2240.20[b]	2254.73[b]	56.03	0.008
Feed intake	4059.03[a]	4016.08[ab]	3970.33[ab]	3588.52[b]	3737.66[ab]	111.78	0.027
FCR (g Feed/g Gain)	1.75[a]	1.74[ab]	1.77[a]	1.61[b]	1.63[ab]	0.03	0.005

Each line represents the mean of six replicate pens with eight birds in each. [ab] - Means in the same row with different superscripts differ significantly ($P < 0.05$).

PFL: prilled palm fat + 2% lysolecithin, FCR: Feed conversion ratio.

[1]The pooled standard error of the means.

[2] n = 48 birds/ group

Nutrient digestibility

There was no significant difference ($P > 0.05$) in the DM digestibility among the dietary treatments (Table 4), whereas there was significantly increased ($P < 0.05$) in OM digestibility in broiler group fed 1% PFL compared to the other treatments. The group of chickens fed 1% PFL showed a significant improvement ($P < 0.05$) in CP compared with the rest of dietary treatments. However, the EE digestibility was higher ($P < 0.05$) than those groups fed 5% or 7% PFL. It was reported by Akit *et al.,* (2018) that lecithin is an emulsifier that proposed to increase the capacity of bile salt micelles to solubilize long-chain saturated fatty acids, thus improving animal fat digestion and absorption. It was also mentioned by Soares *et al.,* (2020) that higher ether extract digestibility was observed for the ration with 22% CP in broiler under heat stress because of the higher inclusion of oil in such formulation, which favors the indirect absorption of amino acids by the extra-caloric effect of fats. The OM, CP, and EE digestibilities were significantly decreased ($P < 0.05$) for those group of birds fed 5% or 7% PFL in their diets compared to those birds fed 1% PFL. The reduction could be attributed to the increase of saturated to the unsaturated fatty acids ratios for those birds fed a high amount of PFL. The findings are in agreement with Jansen *et al.,* (2015), who attributed the reduction in DM digestibility on the change of unsaturated to saturated fatty acids of the feed for the source of fat. In respect of the source of fat, it was reported that weanling pigs fed a diet containing 3% beef tallow and supplemented with 0.05% or 0.1% lysophospholipids, as an emulsifier, led to a significant increase in the DM and EE compared with the unsupplemented group (Zhao *et al.,* 2015). A similar finding was indicated by Jansen *et al.,* (2015) when they supplemented emulsifier to broiler diet. The improvement was observed in the digestibility of DM, EE, and apparent metabolizable energy in broiler fed diet containing pig lard. On the other hand, no significant improvement in the broiler group fed a diet containing soybean oil and supplemented with an emulsifier.

Table 4. Effect of feeding different levels of PFL on dry matter, organic matter, crude protein and crude fat digestibility of broiler.

Parameter (%) [2]	Dietary treatment (PFL%)					*SEM*[1]	*P-value*
	0	1	3	5	7		
Dry matter	92.46	94.03	92.45	91.68	90.53	0.41	0.0791
Organic matter	89.09[bc]	93.74[a]	88.52[bc]	85.05[cd]	81.70[d]	1.12	0.0011
Crude protein	87.90[b]	93.05[a]	87.26[b]	88.23[b]	82.26[c]	1.00	0.0011
Ether extract	82.32[b]	93.46[a]	91.51[a]	86.01[b]	82.29[b]	1.20	0.0001

Each line represents the mean of six replicate pens with eight birds in each. [abcd] - Means in the same row with different superscripts differ significantly ($P < 0.05$).
PFL: prilled palm fat + 2% lysolecithin.
[1] The pooled standard error of the means.
[2] n = 6

Table 5. Effect of feeding different levels of PFL on carcass characteristics of broiler chickens

Parameter (%) [2]	Dietary treatment (PFL%)					*SEM*[1]	*P-value*
	0	1	3	5	7		
Carcass yield	76.95	77.94	74.94	73.70	74.05	0.73	0.08
Wing yield	9.49	9.88	9.62	9.28	9.16	0.10	0.26
Breast yield	36.95	35.97	35.90	35.27	36.66	0.28	0.64
Legs yield	25.83	26.89	28.69	27.67	25.98	0.29	0.06
Abdominal Fat	2.04	2.01	2.52	1.84	1.77	0.08	0.34

Each line represents the mean of six replicate pens with eight birds in each.
PFL: prilled palm fat + 2% lysolecithin
[1] The pooled standard error of the means.
[2] n = 12

Carcass characteristics

The effects of feeding different levels of PFL on carcass and carcass cut of broiler are shown in Table 5. No differences were observed among the dietary treatments. These findings are consistent with Roy *et al.,* (2010), who reported that supplementation of emulsifier to broiler diets containing palm oil did not improve the carcass characteristics significantly. The results in agreement with Guerreiro Neto *et al.,* (2011), who mentioned that carcass characteristics did not improve for broiler chickens fed the diet supplemented with an emulsifier.

Meat quality

The effects of feeding different levels of PFL on meat pH, water holding capacity, meat color, and tenderness are presented in Table 6. No significant differences were observed on pH, cooking loss and drip loss among the dietary treatments. On the other hand, those birds fed the diet supplemented with 5% and 7% PFL showed a significant decrease ($P < 0.05$) in meat color (45.88 and 44.33, respectively) compared to the control group or that birds fed the diet supplemented with 1% PFL. The meat color in the control group; L* 51.30, and those birds fed 1% PFL; 51.37, are considering in the normal range (48< L* < 53), whereas those group of birds fed diets supplemented with 5% or 7% PFL are considering darker than normal (dark L* < 46) (Qiao *et al.,* 2001). The reduction in meat quality in these groups fed with high levels of PFL could be attributed to their lack of growth performance and nutrient digestibility.

Table 6. Effect of feeding different levels of PFL on pH, cooking loss (%), drip loss (%), color and shear force (kg/cm^2) of meat in broiler chickens.

Parameter[2]		Dietary treatment (PFL%)					*SEM*[1]	*P-value*
		0	1	3	5	7		
pH		6.18	6.24	6.27	6.14	6.13	0.05	0.330
Cooking Loss		2.44	3.09	4.55	3.20	4.32	0.33	0.190
Drip Loss		11.51	11.56	12.89	11.77	12.57	0.38	0.570
Color	L*	51.30[a]	51.37[a]	47.11[ab]	45.88[b]	44.33[b]	0.73	0.001
	a*	6.34	7.48	7.95	7.27	7.20	0.34	0.180
	b*	17.13[a]	13.62[a]	12.59[b]	17.74[a]	13.38[a]	0.39	0.001
Shear force		0.85[c]	1.11[bc]	1.48[a]	1.35[ab]	1.20[ab]	0.52	0.020

Values represent the mean of 12 samples per treatment group. [abc] - Means in the same row with different superscripts differ significantly ($P < 0.05$).
PFL: prilled palm fat + 2% lysolecithin.
L*, lightness; a*, redness; b*, yellowness.
[1] The pooled standard error of the means.
[2] n = 12

Serum lipid profile

No significant differences ($P > 0.05$) were found in cholesterol, TAG, HDL-c and LDL-c among the dietary treatments (Fig. 1). The findings are in agreement with Guerreiro Neto *et al.,* (2011), who found no significant differences in blood lipid profile for birds fed diets supplemented with an emulsifier. The results are also consistent with Jansen *et al.,* (2015), who mentioned that no significant differences were observed for those birds fed a diet containing soybean oil and supplemented with an emulsifier. In contrast, the significant differences were found for birds fed diet containing pig lard and supplemented with an emulsifier.

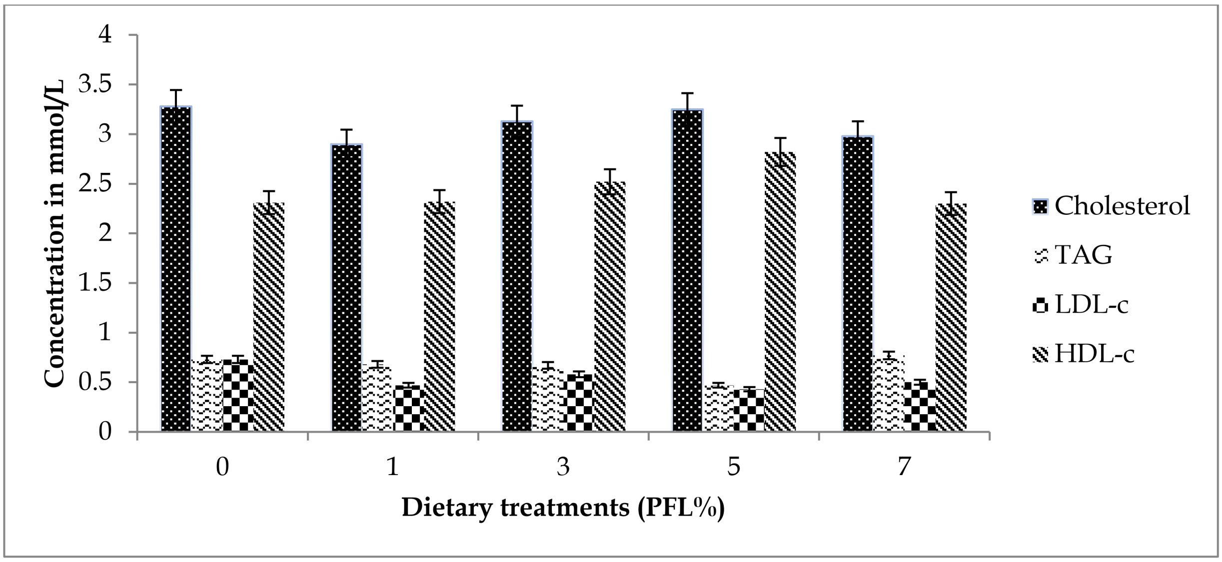

Figure 1. Effect of feeding different levels of PFL on the blood lipid profile (mmol/L) of broiler chickens
TAG: Triacylglycerol; HDL: High-density lipoprotein-cholesterol; LDL-c: Low-density lipoprotein-cholesterol.
Values represent the mean of 12 samples per treatment group.
PFL: prilled palm fat + 2% lysolecithin.

Conclusion

The current study indicated that feeding 1% PFL in broiler diets substantially improved nutrient digestibility as well as BWG and FCR during the overall period. On the other hand, the growth performance, nutrient digestibility, and meat quality decreased as the PFL increased in broiler diets.

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