Effect of free fatty acids supplementation in diet on metabolizable energy growth performance and carcass quality in broiler chickens

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Abstract. Fats are an excellent source of energy and play an important role in the growth of broilers. Using free fatty acids is one of the interesting alternative choices for fats since there is a major metabolic fuel and a part of triacylglycerols. This study was conducted to evaluate the effects of free fatty acids (FFAs) substitution in diet on metabolizable energy, growth performance and carcass quality of broilers. A total of 900 male broiler chicks were divided into 5 groups with 6 replicates of 30 birds each. The birds received a control diet using palm oil as dietary oil supplementation and other groups were substituted with 25, 50, 75 and 100 % FFAs for 35 days. At the end of the feeding trial, the results indicated that all levels of FFAs substitution did not influenced the body weight, feed intake, FCR as well as carcass quality of broilers when compared to the control group. Moreover, there was no significant difference of the metabolizable energy in broilers fed with FFAs. It can be concluded that FFAs is useful as dietary oil supplementation by substitution of palm oil without negative effects on the metabolizable energy, growth performance and carcass quality of broilers.

1 Introduction

Dietary fats and oils, consisting mainly of triacylgecerols, are relatively large molecules and cannot be absorbed intact in the small intestines. The triacylgecerols must be broken down (hydrolyzed) by lipase and colipase, both of which are enzymes produced by the pancreas. The result of the hydrolysis are two free fatty acids and one 2-monoacylglycerol, which can be absorbed by the small intestines. Fats in the diet are a source of essential fatty acids that are important for the growth of broilers

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and also play a vital role in maintaining healthy skin and feathers, insulating body organs against shock, maintaining body temperature, and promoting healthy cell function. Fats are an excellent source of energy, and their inclusion in the diet is the main method of increasing the energy content of poultry diets [1,2]. Various fat sources are available for poultry, such as animal fats (e.g., lard and tallow) and vegetable oils (e.g., palm oil and soybean oil) but these fats may cost the high price. Therefore, the alternative choice is using the other sources of fat such as free fatty acids.

Free fatty acids (FFAs) is a fatty acid which is part of triacylglycerol without glycerol. Fatty acids play a number of key roles in metabolism – major metabolic fuel (storage and transport of energy). To use free fatty acids, it is essential to know the composition of fatty acids in an oil or fat, to identify their characteristics and to know the stability of them [3,4] because [5,6,7] reported that the metabolizable energy was influenced by the unsaturated: saturated (U:S) ratio. Therefore, the objectives of this study were to evaluate the effects of free fatty acids on metabolizable energy, growth performance and carcass quality of broiler chickens.

2 Materials and methods

2.1 Animals and managements

This study was conducted at Animal Research Farm, Department of Animal Science, Faculty of Agriculture, Kasetsart University, Bangkok, Thailand. The experimental animals were kept, maintained and treated in adherence to accepted standards for the humane treatment of animals.

A total of 900 one-day-old male ROSS 308 broiler chicks (average body weight 46.63 g) were used in this trial. Chicks were randomly divided into five treatments and each treatment consisted of six pens (thirty birds per pen). Feed and water were provided ad libitum, while water was supplied by nipple drinkers. All chicks were inoculated with Newcastle disease vaccine and oral vaccination of the infectious bursal disease vaccine on day 10.

The experimental diets (Table 1 and 2) were satisfying the nutritional requirements described in strain's and based on corn and soybean meal. Five dietary treatments were provided to the broilers for 35 days as follows; basal diet (control), and substitution of palm oil by 25, 50, 75, 100 % FFAs, respectively.

The specifications of FFAs that used in the experiment was liquid substance, brown color, 99% minimum of crude fat, 1% maximum of moisture, 70% minimum of free fatty acids, minimum 80 of iodine value, 30 ^{o}C of melting point and fatty acid

composition: 18% palmitic acid, 5% stearic acid, 60% oleic acid, 14% linoleic acid and 3% others.

Table 1. Composition of the basal diet

Ingredient	Starter	Grower	Finisher
Thai Corn	55.01	56.39	62.35
Palm oil	3.48	5.06	4.74
Soybean meal (48% CP)	36.07	34.00	28.72
L-Lysine HCL 78%	0.23	0.08	0.08
DL-Methionine	0.33	0.25	0.21
L-Threonine	0.08	0.01	0.01
Monodicalciumphosphate21%	2.19	1.92	1.77
Calcium carbonate	1.51	1.25	1.22
Salt	0.30	0.30	0.30
Premix[a]	0.55	0.53	0.40
Choline Chloride 75%	0.25	0.23	0.22
Total	100.00	100.00	100.00
Calculated chemical composition Metabolizable energy (MJ/kg)	3,025	3,150	3,200
Protein (%)	22.10	21.00	19.00
Fat (%)	5.75	7.32	7.17
Calcium (%)	1.05	0.90	0.85
Total Phosphorus (%)	0.85	0.78	0.73
Available phosphorus (%)	0.50	0.45	0.42
Salt (%)	0.32	0.32	0.32
Lysine (%)	1.27	1.10	0.97
Methionine (%)	0.94	0.84	0.76
Methionine+Cystein (%)	0.63	0.54	0.48
Threonine (%)	0.83	0.73	0.65
Tryptophan(%)	0.24	0.23	0.20
Valine (%)	0.95	0.91	0.82

[a]Premix content; Composition per 1 kg: Vitamin A 4.8 MIU, Vitamin D3 1.2 MIU, Vitamin E 6,000 IU, Vitamin K3 0.6 g, Vitamin B1 0.6 g, Vitamin B2 2.2 g, Vitamin B6 0.8 g, Vitamin B12 0.004 g, Nicotinic acid 10 g, Pantothenic acid 4.8 g, Folic acid 0.2 g, Biotin 0.048 g,

Manganese 32 g, Zinc 24 g, Iron 16 g, Copper 3.2 g, Iodine 0.2 g, Cobalt 0.04 g, Selenium 0.04 g

2.2 Growth performance

The initial body weight of each chick was recorded at the beginning of the feeding trial (day 1). The body weight, body weight gain and feed intake were measured on the feed switching time basis, which means evaluating on 10, 24 and 35 days in order to calculate average daily gain (ADG) and feed conversion ratio (FCR) and the mortality of broilers were observed.

2.3 Carcass quality

At the end of the finisher period (35 days), 2 birds per replicate (showing closest to the average body weight of the pen) were selected in order to determine the carcass quality as following; live weight, slaughter weight, carcass weight, inner breast weight, outer breast weight, thigh weight, drumstick weight, wing weight and abdominal fat.

2.4 Metabolizable energy

Four days prior to the end of the finisher period (day 31), 4 birds per unit were moved to the metabolic cage for metabolizable energy examination. Birds were fed with the experimental feed containing 0.5% Cr_2O_3 as the external marker and using celiteTM and AIA (Acids Insoluble Ash) as internal markers. Feed was provided for 80% of recent daily feed consumption and clean collection trays were placed beneath each cage and excreta was collected in labeled plastic bags.

The retention time was determined by the excreta color changing from a normal color to a light green color (color from Cr_2O_3). Then excreta were pooled, homogenized, weighed to 100 g and immediately dried for further analysis (dry matter, gross energy and AIA) in order to calculate metabolizable energy [8].

2.5 Statistical analysis

Analysis of variance was conducted using pen means. All statistical analyzes were performed by ANOVA using SAS statistical program. [9] Differences among treatments were determined with Duncan's multiple range test [10]. Statements of statistical significance were based on $P<0.05$. Then the data were analyzed by regression analysis based on the data that was in response to the increasing levels of FFAs in linear and quadratic equations to predict the levels of FFAs.

3 Results

3.1 Growth performance

The growth performances of broilers are shown in Table 2. All broilers remained in good health throughout the trial. All FFAs substitution levels (25%, 50%, 75% and 100%) did not influence the body weight of starter, grower, finisher period and overall trial (35 days) when compared to the control group and linearly increased the FCR of the overall trial. Substitution of FFAs linearly increased the feed intake and FCR in the starter period. However, the feed intakes of the overall trial (35 days) were not significantly influenced by the FFAs

The results of this study indicated that FFAs did not statistical significance ($P>0.05$), but they suggest a possible negative effects on broiler performances, which is in agreement with the report of Pesti et al. (2002) [11]. The body weight of broilers fed diets containing FFAs in finisher and overall performance were lower than those of birds fed with a control diet, suggesting that the energy in diets with a higher FFAs content was not utilized as efficiently as the energy in diets with a lower FFAs content [12]. Shannon (1979) [13] and Sklan (1979) [14] reported that the absorption of fatty acids was higher in chicks fed triglycerides than in chicks fed FFAs. Their results suggested a need for glycerides for the efficient solubilization and absorption of FFAs. The cause of lower body weight could be that the diets with higher FFAs levels were associated with some chemical, physical, or physiological characteristic that reduced palatability and feed intake [15].

There were many factors shown to affect the utilization of fats, such as the age of the chicken [16-17], the degree of saturation of fatty acids [18-23], and the chain length of the fatty acid [18], as well as positional effects of fatty acids on the triglyceride molecule [19]. Therefore, in this study, the lower body weight of broilers fed FFAs might be caused by the high levels of FFAs and the high ration of U:S.

Table 2. Effect of free fatty acids supplementation in diet on growth performance of broilers**.**

Item	Free fatty acids					P-Value	SEM	Contrast, P<	
	0%	25%	50%	75%	100%			Linear	Quadratic
Starter (d 1 to 10)									
BW (g/b)	344.41	345.60	342.64	345.27	347.64	0.83	1.22	0.50	0.50
FI (g/b/d)	34.97	35.01	35.36	36.11	36.68	0.15	0.26	0.01	0.48
BWG (g/b)	297.77	298.96	296.31	298.75	301.02	0.83	1.21	0.49	0.50
ADG (g/b/d)	29.78	29.90	29.63	29.88	30.10	0.82	0.12	0.49	0.50
FCR	1.17	1.17	1.19	1.21	1.22	0.27	0.01	0.03	0.80
Grower (d 11 to 24)									
BW (g/b)	1,375.25	1,350.70	1,352.03	1,358.10	1,347.17	0.47	5.19	0.20	0.47
FI (g/b/d)	99.11	96.34	97.75	97.75	97.80	0.40	0.43	0.69	0.25
BWG (g/b)	1,030.84	1,005.09	1,009.08	1,012.73	999.53	0.25	4.58	0.09	0.51
ADG (g/b/d)	73.63	71.79	72.08	72.34	71.40	0.25	0.33	0.09	0.51
FCR	1.35[b]	1.34[b]	1.36[ab]	1.35[b]	1.37[a]	<0.01	0.00	<0.01	0.26
Finisher (d 25 to 35)									
BW (g/b)	2,432.51	2,382.84	2,409.10	2,364.72	2,363.75	0.40	13.01	0.10	0.81
FI (g/b/d)	165.36	163.33	162.94	161.75	163.25	0.69	0.75	0.30	0.34
BWG (g/b)	1,057.27	1,032.14	1,057.07	1,006.62	1,016.57	0.51	11.14	0.19	0.96
ADG (g/b/d)	96.11	93.83	96.10	91.51	92.42	0.51	1.01	0.19	0.96
FCR	1.72	1.74	1.70	1.77	1.77	0.50	0.01	0.23	0.63
Overall (d 1 to 35)									
BW (g/b)	2,432.51	2,382.84	2,409.10	2,36472	2,363.75	0.40	13.01	0.10	0.81
FI (g)	3,556.23	3,495.46	3,514.36	3,508.79	3,531.69	0.50	11.15	0.66	0.14
BWG (g/b)	2,385.87	2,336.19	2,362.46	2,318.10	2,317.13	0.40	13.01	0.10	0.81
FCR	1.49	1.50	1.49	1.52	1.53	0.21	0.01	0.04	0.47

[a,b] Means within a row with different letters differ significantly (P<0.05

3.2 Carcass quality

Substitution of FFAs linearly reduced slaughter weight, carcass weight and outer breast weight (Table 3) and there were non-significant differences in the other carcass yields (inner breast weight, thigh weight, wing weight, drumstick weight, abdominal fat weight and liver weight). Peebles et al. (1999) [24] reported that birds fed with less saturated fatty acid in the diet improved slaughter yield. Since the carcass quality was affected by the fatty acids profile, therefore, the carcass quality had no significant difference in broilers fed with FFAs.

Table 3 Effect of free fatty acids supplementation in diet on carcass quality of 35 days old broilers.

Item (g)	Free fatty acids					P-Value	SEM	Contrast, P<	
	0%	25%	50%	75%	100%			Linear	Quadratic
Live weight	2,369.17	2,309.25	2,321.67	2,287.00	2,290.75	0.25	12.75	0.05	0.45
Slaughter weight	2,205.08	2,152.50	2,163.92	2,115.92	2,119.83	0.11	12.04	0.02	0.57
Carcass weight	1,935.50	1,890.42	1,901.83	1,855.17	1,848.75	0.09	11.41	0.01	0.83
Inner breast weight	82.67	84.08	84.5	83.42	80.83	0.82	1.01	0.57	0.29
Outer breast weight	420.75	418.33	406.67	395	398.42	0.20	4.21	0.03	0.73
Thigh weight	290.83	279.50	291.17	279.67	277.00	0.28	2.69	0.15	0.79
Drumstick weight	227.25	221.75	228.42	221.08	222.42	0.78	2.19	0.53	0.99
Wing weight	174.17	171.83	174.83	162.92	166.83	0.20	1.87	0.08	0.87
Abdominal fat weight	48.77	46.43	44.81	48.77	45.72	0.76	1.14	0.66	0.68
Liver	46.82	45.01	45.80	43.76	45.71	0.68	0.65	0.47	0.41

3.3 Metabolizable energy

The effect of FFAs on metabolizable energy of 31 days-old broilers is shown in Table 4. The substitution of FFAs in 25, 50, 75 and 100% were not affected the metabolizable energy of broilers at 31 days of age. Vilà and Esteve-Garcia (1996a, b, c) [5-7], reported that the metabolizable energy was influenced by the unsaturated: saturated (U:S) ratio and that increased concentrations of saturated FFA decreased the metabolizable energy content, which in agreement with Wiseman et al. (1991) [25], who showed that increasing the proportion of FFAs while reducing the U:S ratio was associated with lower metabolizable energy, whereas increasing the FFAs with increase in the U:S ratio slightly improved the metabolizable energy. Therefore, the metabolizable energy in this study was increased due to the high ratio of U:S.

Table 4 Effect of free fatty acids supplementation in diet on metabolizable energy of 31 days old broilers.

Item	Free fatty acids					*P*-Value	SEM	Contrast, P<	
	0%	25%	50%	75%	100%			Linear	Quadratic
ME (Cal/kg)	3,110.17	3,135.08	3,184.77	3,141.53	3,167.84	0.11	9.54	<0.01	<0.01

4. Conclusion

In conclusion, FFAs substitution at 25%, 50%, 75% and 100% in diets had no negative effect to the body weight when compared to the control group. The carcass quality was not affected by FFAs. Moreover, there was no significant difference of the metabolizable energy in broilers fed with FFAs.

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