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Effects of Crude Glycerin from Palm Oil Biodiesel Production as a Feedstuff for Broiler Diet on Growth Performance and Carcass Quality

Nusawan Boonwong, Chaiyawan Wattanachant* and Sutha Wattanasit

Department of Animal Science, Faculty of Natural Resources, Prince of Songkla University, 90112 Songkhla, Thailand

ABSTRACT

The effects of crude glycerin, a by-product from palm oil biodiesel production, supplemented in broiler diet on growth performance and carcass quality were studied. Four hundred 1-day-old-male Cobb 500 were randomly allotted into a completely randomized design of five groups consisting of four replications per group. Control diet and diets containing with 2.5%, 5%, 7.5%, and 10% of glycerin in pellet form were fed *ad libitum* to the broilers from 1 day of age until the age of 42 days. At the end of the experiment, eight broilers per treatment were slaughtered for carcass quality study. From the results, no significant difference was found in live weight change and feed intake with those receiving diets with and without glycerin supplementation. However, low growth performance and carcass yield were indicated when the levels of glycerin increased, particularly at 10%. No effect of dietary treatments on physical properties of the breast meat ($P > 0.05$). Therefore, this study recommended for mixing crude glycerin not >5% in the broiler diets. Furthermore, the inclusion of glycerin in the diets did not show any influence on the pH, tCIE color, shear force, drip, and cooking loss percentages of the breast meat ($P > 0.05$).

Keywords: Broiler, carcass quality, crude glycerin, growth performance

INTRODUCTION

Biodiesel production has grown over the past several years due to the rising of world fossil fuel prices. Crude glycerin is the main by-product of biodiesel production, which is usually used for various purposes such as fuel, lubrication, animal diet, and so on. However, the quality of crude glycerin in terms of physical property and chemical

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E-mail addresses:
nusawan_nr@hotmail.com (Nusawan Boonwong)
chai_tum@yahoo.com (Chaiyawan Wattanachant)
sutha.v@psu.ac.th (Sutha Wattanasit)
* Corresponding author

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composition is quite variable depending on sources of oil used for the biodiesel production (Dasari, 2007; Kerr, Dozier, & Bregendahl 2007; Thompson & He, 2006).

In terms of animal feed production, crude glycerin is mostly supplemented in animal diet, which is a by-product from biodiesel plants, that can substitute corn or sorghum as a source of energy (Thompson & He, 2006; Dasari, 2007; Kerr et al., 2007). In broiler feed, it could be substituted corn for about 5%–10% (Silva et al., 2012), although low weight gain in the second stage of broiler raising was indicated when fed diet with 10% of crude glycerin (Cerrate et al., 2006). In Thailand, preliminary work of Settapong et al. (2015) summarized that 10% of crude glycerin from the medium-scale biodiesel plant, which used waste cooked oil and a source of production (consisting of 80.25% purity, 4,387.45 GE/kg, and 0.44% crude fat), did not affect the growth performance of broiler. Nevertheless, not much information on the utilization of crude glycerin by-product from a palm oil biodiesel plant in animal feeds has been reported, in particular for broiler. Therefore, the objective of this study was to evaluate the influence of crude glycerin from palm oil biodiesel production added as an energy source in broiler diets on growth performance and carcass quality.

MATERIALS AND METHODS

Broilers and Management

This study was conducted at the Chicken Unit, Department of Animal Science, Faculty of Natural Resources, Prince of Songkla University (PSU), Hat Yai, Thailand. A total number of four hundred of 1-day-old-male Cobb 500 chicks with 44.45 ± 0.19 g of initial live weight from Charoen Pokphan Food (Thailand) Co. Ltd. (CPF) were allotted into five treatments, four replicates of 20 birds each. All birds were raised to receive experimental diets in the evaporative closed house system for 42 days (6 weeks). All procedures involved with this experimental broilers were in accordance with the animal ethical standard of the responsible committee on animal experimentation, PSU, while broiler farm management followed the recommended standard code number TAS 6901-2009 of the National Bureau of Agricultural Commodity and Food Standards, Ministry of Agriculture and Cooperatives, Thailand (ACFS, 2009).

Feeds and Feeding

Five diets consisting of 0%, 2.5%, 5.0%, 7.5%, and 10% of crude glycerin were formulated to supply the broiler's nutrient requirements according to the National Research Council (NRC, 1994). Diets were then mixed and pelleted at Animal Feed Mill Unit, Department of Animal Science, PSU. Crude glycerin used in this study was acquired from New Biodiesel Co., Ltd., Suratthani province, Thailand (a commercial palm oil biodiesel production plant). And its composition was determined by Settapong (2013) as 87.65% purity, 4,650 kcal/kg, 0.22% EE, 0.48% CP, and 1.44% ash. Ingredients and calculated nutritional values of the five mixed diets are presented in Table

1. The feeding program during this study was divided into two stages according to the management system: starter (1st stage) from 1 to 21 days (or 1–3 weeks) and finisher (2nd stage) from 22 to 42 days (4–6 weeks) of age. During the study, chickens were offered feed and water *ad libitum*.

Table 1
Ingredient composition and calculated nutrient content of the five experimental diets (1–21 and 22–42 days of age)

Items	Glycerin (%)*									
	1st stage (1–21 days of age)					2nd stage (22–42 days of age)				
	0	**2.5**	**5**	**7.5**	**10**	**0**	**2.5**	**5**	**7.5**	**10**
Ingredients										
Corn	55.25	52.21	49.17	46.14	43.10	62.61	59.75	56.89	53.52	50.92
Soy bean meal	29.59	30.13	30.66	31.20	31.74	21.78	22.31	22.84	23.38	23.91
Fish meal	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Vegetable oil	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Dicalcium phosphate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
DL-met	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Lys	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Crude glycerin[1]	0.00	2.50	5.00	7.50	10.00	0.00	2.50	5.00	7.50	10.00
Rice hulls	0.00	0.00	0.00	0.00	0.00	0.44	0.27	0.10	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated values										
Crude protein, %	23	23	23	23	23	20	20	20	20	20
ME, kcal/kg	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200
Ca, %	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90
Met, %	0.50	0.50	0.50	0.50	0.50	0.38	0.38	0.38	0.38	0.38
Lys, %	1.10	1.10	1.10	1.10	1.10	1.00	1.00	1.00	1.00	1.00
Thr, %	0.80	0.80	0.80	0.80	0.80	0.74	0.74	0.74	0.74	0.74
Sodium, %	0.20	0.20	0.20	0.20	0.20	0.15	0.20	0.15	0.15	0.15
Calcium, %	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90
Non-phytate phosphorus, %	0.45	0.45	0.45	0.45	0.45	0.35	0.35	0.35	0.35	0.35
Lysine, %	1.10	1.10	1.10	1.10	1.10	1.00	1.00	1.00	1.00	1.00
Methionine, %	0.50	0.50	0.50	0.50	0.50	0.38	0.38	0.38	0.38	0.38
Threonine, %	0.80	0.80	0.80	0.80	0.80	0.74	0.74	0.74	0.74	0.74
Sodium, %	0.20	0.20	0.20	0.20	0.20	0.15	0.15	0.15	0.15	0.15

*Containing 87.65% purity, 4,650 kcal GE/kg, 0.22% EE, 0.48% CP, 1.44% ash, and 6.40 of pH (Settapong, 2013)

Managements and Data Collection

Performance parameters such as live weight, average daily gain (ADG), feed intake, and feed conversion ratio (FCR) were obtained for each raising stage. At the end of this study, eight chickens per treatment were sampled to fasting for about 12 h before being slaughtered at the Department of Animal Science, PSU slaughterhouse. Fasted live weight was determined before slaughter, while the slaughtering procedure used in this study was done according to the Islamic procedure of Thai Agricultural Standard 8400-2007 (ACFS, 2007). After slaughter, weight of carcasses and organs were determined, whereas pH at 45 min *post mortem* (pH_0) of breast muscle (m. *Pectoralis major*) at the right side of each carcass was obtained. Then the carcasses were individually packed in plastic bags and stored at 4°C for about 24 h. After this period, each carcass was weighed and the ultimate pH (pH_μ) of the breast muscle determined. After that, commercial parts; breast, fillet, thigh, drumstick, and wing were cut and weighted. The procedure of the chicken meat cutting part was done according to the guidelines of Thai Agricultural Standard 6700-2005 (ACFS, 2005). Color, shear force, and cooking loss values of breast muscle of each carcass were determined according to Wattanachant (2004). In this study, the pH of muscle was measured using a MettlerTeledo portable pH meter model SG2 with Mettler pH probe (Lot 406-M63DXK-57/25). Breast muscle color was determined with a CR-10 Chromometer (Minolta Color Meter, Osaka, Japan) and reported in the CIE color system. The shear force value was measured by a Texture Analyzer (TA-XT2i, Texture expert Vision 1.17, Stable Micro System, Godalming, Surrey, UK) by using a Warner-Bratzler shear blade.

Statistical Analysis

The data were analyzed as a completely randomized design by using the GLM procedure. Mean comparisons were performed by the Duncan's multiple range test according to Kaps and Lamberson (2004).

RESULTS AND DISCUSSION

Growth Performance

The effects of the dietary treatments on growth performance are presented in Table 2. During the first stage of rearing, broilers that received control diet with no crude glycerin inclusion had higher live weight, live weight gain, ADG, and feed intake ($P < 0.01$) than other treatment diets. However, those fed 2.5% and 5.0% glycerin had significantly better live weight gain compared to those fed diet with 10% glycerin inclusion. No effect of dietary treatments on FCR ($P > 0.05$) was found at this stage.

In the second stage, broilers fed control diet with no glycerin and the inclusion of 2.5%–10% of crude glycerin had no significant effects on final live weight, live weight gain, and ADG ($P > 0.05$), although the final weight of the control diet tended to be higher than others. In this stage, broilers fed control diet with no glycerin inclusion had similar feed intake as those fed diet with 2.5%–7.5% of glycerin, but the feed intake of all these three groups were significantly higher than those fed 10% glycerin (*P* < 0.05). After calculation of FCR, this study indicated that dietary treatments either with or without glycerin inclusion did not show any significant effect on FCR of broilers (*P* > 0.05).

During the period of 1–42 days of age, no significant effects of dietary treatments were found in live weight change, ADG, and FCR (*P* > 0.05). Feed intake in broilers fed control diet and those fed with diets supplemented with 2.5% and 5.0% of crude glycerin (*P* > 0.05) was similar, but statistically higher than those fed 7.5% and 10% of crude glycerin (*P* < 0.05). From this study, it was observed that feed intake of broilers decreased when the percentage of crude glycerin inclusion in the diets increased. Thus, FCR of broilers tended to decrease due to the lesser feed intake when the level of glycerin increased.

The reduction in growth performance was related to the amount of crude glycerin inclusion in the dietary treatment,

Table 2
Live weight change, feed intake, FCR of broilers receiving diets containing 0, 2.5, 5, 7.5, and 10% of crude glycerin (n = 400)

Items	Crude glycerin (%)					SEM	*P*-value
	0	2.5	5	7.5	10		
Initial weight (g)	44.50	44.20	44.45	44.10	44.65	0.28	0.7518
1–21 days (1st stage)							
Final weight (g)	887.50[a]	797.50[b]	812.50[b]	746.25[bc]	717.50[c]	22.42	0.0008
Weight gain (g)	843.00[a]	753.30[b]	768.05[b]	702.15[bc]	672.85[c]	22.33	0.0008
ADG (g)	40.14[a]	35.87[b]	36.57[b]	33.44[c]	32.04[d]	1.06	<0.0001
Feed intake (g/bird)	1,131.30[a]	989.63[b]	1,003.98[b]	934.13[bc]	877.05[c]	23.48	<0.0001
FCR	1.34	1.31	1.31	1.33	1.31	0.13	0.1339
21–42 days (2nd stage)							
Final weight (g)	,710.00	2659.00	2690.00	2570.00	2560.00	35.67	0.0589
Weight gain (g)	1822.50	1861.50	1877.50	1833.75	1842.50	112.43	0.9799
ADG (g)	86.79	88.64	89.40	86.39	87.74	5.35	0.9799
Feed intake (g/bird)	3920.51[a]	3949.31[a]	3940.83[a]	3782.08[ab]	3545.48[b]	48.12	0.0480
FCR	2.15	2.12	2.10	2.06	1.92	0.11	0.5042
1–42 days							
Final weight (g)	2710.00	2659.00	2690.00	2570.00	2560.00	35.67	0.0689
Weight gain (g)	2665.50	2614.80	2645.55	2535.90	2515.35	28.97	0.0429
ADG (g)	63.46	62.26	62.99	60.38	59.89	1.04	0.0305
Feed intake (g/bird)	5091.81[a]	4938.90[a]	4964.80[a]	4736.21[b]	4322.53[c]	147.59	0.0335
FCR	1.88	1.86	1.85	1.86	1.72	0.09	0.0794

[a,b,c]Means on the same rows with different superscripts differ significantly (*P* < 0.05)

particularly at 10% inclusion, during the first stage of rearing (1–21 days). This finding confirms the work of Cerrate et al. (2006) who reported that the addition of 10% glycerol to the diet caused a similar live weight to fed diets with 0% and 5% glycerol at 14 days of age. Nevertheless, the results of this study are different from the trial executed by Silva et al. (2012) who found no statistical difference of the dietary inclusion of 10% of glycerin during the rearing period on growth performance. In addition, other reports with adding glycerin at 8% in broiler diet (Abd-Elsamee et al., 2010) and 10% in broiler diet (Settapong, 2013) did not observe any impairment of growth performance. However, this study can conclude that broilers fed diets with 2.5% and 5% of glycerin inclusion might perform better than those received diet with 7.5% and 10% of crude glycerin. During the second stage (22–42 days), although growth performance of broilers fed diets with crude glycerin inclusion from 2.5% to 10% did not show any statistically differences, growth performance tended to be lower than those broilers fed control diet. This finding was similar to the report of Silva et al. (2012) although the result of this study for live weight was about 16.7% lower. Feed intake tended to decrease when the level of glycerin inclusion increased, similar to the findings of Jung and Batal (2011) and Silva et al. (2012). This reduction of weight gain might not be related to the effect of methanol in glycerin ingredient due to the low percentage of methanol (1.02%). Thus, the low weight gain is probably related to the hardness of the pellet feed that altered the flowability of feed in the gut described by Cerrate et al. (2006).

Carcass Characteristics and Physical Properties of Meat

Table 3 illustrates the carcass trait results of broilers at 42 days of age. No significant effect of treatment diets on the slaughter weight, warm carcass weight, chilled carcass weight, dressing percentage, and visceral percentage were obtained ($P > 0.05$), although warm and chilled carcass weights tended to decrease when the percentage of glycerin inclusion increased. Considering the retail parts (Table 4), broilers receiving control diet with no crude glycerin had similar breast percentage with those fed 2.5%–7.5% of glycerin ($P > 0.05$), whereas the lowest breast percentage was indicated in broilers fed 10% crude glycerin ($P < 0.05$). No significant differences were detected in increasing glycerin levels on fillet, drumstick, wing, and thigh percentages ($P > 0.05$). It was noticed that the thigh percentage tended to increase, while the breast percentage tended to decrease when the level of glycerin inclusion increased. This work was different from the report of Cerrate et al. (2006) who found a significant increase of breast percentage in broilers fed with 5% as compared to those fed diets with 0% and 2.5% of glycerin with no significantly difference in breast percentage of broilers fed diets containing 5% and 10% of glycerin ($P > 0.05$). The low meat yield in this study might be related to the low protein depot in the carcass. When comparing results of this study to other literatures, there was a positive effect found on carcass traits. This could be described that with suitable amount of glycerin, it might increase the protein deposition in broiler due to the reduction of gluconeogenic amino acid via the inhibition of phosphoenolpyruvate carboxykinase as described by Young, Shrago and Lardy (1964), Cryer and Bartly (1973), and Silva et al. (2012). Glycerin was also observed to decrease the activity of glutamate dehydrogenase (Steele, Winkler, & Altszuler, 1971).

The inclusion of glycerin in the diets did not show any influence on the pH and the color of the breast meat neither at 45 min post-mortem time nor 24 h post-mortem time ($P > 0.05$) (Table 5). In addition, shear

Table 3
Carcass components of broilers received diets containing 0, 2.5, 5, 7.5, and 10% of crude glycerin

Items	Crude glycerin (%)					SEM	*P*-value
	0	2.5	5	7.5	10		
Number of broiler, birds	8	8	8	8	8	–	–
Slaughter weight (g)	2600.00	2598.50	2600.00	2541.88	2536.00	94.84	0.2447
Warm carcass weight (g)	1860.50	1838.50	1832.50	1796.50	1790.20	78.56	0.1901
Chilled carcass weight (g)	1839.00	1804.50	1804.00	1772.50	1760.93	65.97	0.0769
Dressing percentage							
Warm carcass, (%)	71.56	70.75	70.48	70.68	70.59	0.49	0.6977
Chilled carcass (%)	70.73	69.44	69.38	69.73	69.44	0.55	0.6880
Viscera (%)	10.68	10.55	10.86	10.40	10.37	0.22	0.5577

[a,b,c]Means on the same rows with different superscripts differ significantly ($P < 0.05$)

Table 4
Carcass composition of broilers receiving diet containing 0, 2.5, 5, 7.5, and 10% of crude glycerin

Items (%)	Crude glycerin (%)					SEM	*P*-value
	0	2.5	5	7.5	10		
Breast	25.8[a]	24.55[a]	24.75[a]	24.13[ab]	23.21[b]	0.64	0.0301
Fillets	5.40	5.46	5.67	5.61	5.45	0.14	0.0798
Drumsticks	13.5	13.43	14.09	13.85	13.95	0.35	0.9960
Wings	11.4	11.12	10.97	11.18	11.3	0.41	0.5813
Thighs	17.68	18.47	18.21	18.30	18.39	0.42	0.0590
Meat	58.42	57.14	57.20	56.30	56.85	1.25	0.0653
Bone	27.86[b]	28..89[a]	29.12[a]	30.55[a]	30.99[a]	0.63	0.0456
Total fat	8.32	8.26	8.20	7.90	7.91	0.22	0.5127

[a,b,c]Means on the same rows with different superscripts differ significantly ($P < 0.05$)

force, drip, and cooking loss percentages of the breast meat from broilers fed all treatment diets did not show any significant differences ($P > 0.05$). This was probably related to the amount of crude glycerin inclusion in this study that was in the typical range recommended by other works of Cerrate et al. (2006) and Silva et al. (2012). No negative effects on meat traits were indicated, although weight change and feed intake were decreased when the level of glycerin increased. The pH of meat in this study was in the normal range (6.10–6.19) mentioned by Ristic and Damme (2010), although the pH at 45 min in this study was slightly lower (6.25) compared to the report of Karaoğlu, Aksu, Esenbuga, Macit and Durdag (2006). This was probably related to the amount of glycogen stored in the muscle during slaughter period described by Haslinger, Leitgeb, Bauer, Ettle and Windisch (2007). The lighter L* value of breast meat at 24 h post-mortem was in agreement with the work of Qiao, Fletcher, Smith and Northcutt (2001), and Petracci and Fletchert (2002).

Table 5
pH at 45 min and 24 h post-mortem and color of breast muscle from broilers received diet containing 0, 2.5, 5, 7.5, and 10 % of crude glycerin

Item	Crude glycerin (%)					SEM	*P*-value
	T1	T2	T3	T4	T5		
45 min (pH_0)							
pH	6.16	6.14	6.11	6.10	6.19	0.04	0.4693
L	43.39	43.23	43.27	44.57	44.23	0.48	0.1731
a*	1.65	1.68	1.65	1.69	1.71	0.06	0.9566
b*	2.60	2.69	2.59	2.68	2.64	0.07	0.8095
24 h (pH_μ)							
pH	5.79	5.75	5.77	5.83	5.84	0.02	0.0675
L	46.44	45.98	44.99	47.14	46.44	0.56	0.1109
a*	1.66	1.59	1.60	1.69	1.66	0.04	0.2587
b*	1.79	1.74	1.75	1.72	1.69	0.05	0.6244
Drip loss (%)	1.45	1.48	1.57	1.67	1.71	0.10	0.2642
Cooking loss (%)	18.83	17.93	18.76	18.42	17.62	0.66	0.5898
Shear force (g*)	2,790.88	2,762.74	2,801.24	2,980.81	2,998.68	170.38	0.5615

*Muscle samples were cut approximately to a dimension of 1 × 2 × 0.5 cm. Crosshead speed was set to 2 mm/s and 25 kg load cell

CONCLUSION

The results of this study indicated that crude glycerin from palm oil biodiesel production could be used to substitute corn in broiler diet. However, low growth performance and carcass yield were indicated when the levels of glycerin exceeded 5% of the diet. From the results of this study, the optimum amount of crude glycerin recommended in the broiler diets is no >5%. However, the replacement of corn by crude glycerin will not be suitable if the price of corn is lower than the price of glycerin.

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