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Energy digestibility in broilers and poult performance when fed palm or soybean oil with or without glyceryl monolaurate

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ABSTRACT

Two trials were conducted to determine interactive effects between lipid source (palm oil, **PO** versus soybean oil, **SO)** and emulsifier addition (none versus glycerol monolaurate-**GML**) on apparent total tract digestibility (**ATTD**) of gross energy (**GE**) in broilers and growth performance in poults. In trial 1, 0.05 % GML addition had no impact on the ATTD of GE of SO but improved the ATTD of PO from 77.11 % to 88.21 % (interaction, P=0.03). Without GML addition, PO had a lower ATTD of GE (77.11 %) compared to SO (96.48 %) resulting in an AME of 7,259 versus 9,092 kcal/kg for PO and SO, respectively. In trial 2, the addition of 0.10 % GML reduced ADFI in poults fed diets containing 5 % PO compared to poults fed 0 or 0.05 % GML, while the addition of either 0.05 or 0.10 % GML reduced ADFI in poults fed diets containing 5 % SO compared to poults fed no GML (P=0.01). There was a similar response with ADG (P=0.01) where the addition of either 0.05 or 0.10 % GML reduced ADG in poults fed diets containing SO compared to poults fed no GML, while the addition of GML was largely without effect in poults fed diets containing PO. There was no interaction between lipid source and emulsifier addition on feed efficiency (P>0.10). Poults fed diets containing PO had a poorer feed efficiency compared to birds fed diets containing SO (P=0.01). The main effect of emulsifier was inconsistent in that poults fed the diets containing 0.10 % GML had the greatest feed efficiency compared to poults fed the diets containing 0.05 % GML, with poults fed diets containing no emulsifier being intermediate (P=0.10). In conclusion, addition of GML improved the ATTD of GE for PO but had no effect on the ATTD of GE for SO. This improvement in energy digestibility, did not however, translate to an improvement in poult performance. Broilers and poults fed diets containing SO had a greater feed efficiency compared to birds fed diets containing PO.

Introduction

Energy is a costly component in poultry diets with fats and oils (lipids) being an important part of meeting these needs because of their energy concentration (Kerr et al., 2015). Two of the primary vegetable oils produced globally are palm oil (**PO**) and soybean oil (**SO**). Palm oil is largely produced in Indonesia and Malaysia and is used in a wide range of food and industrial products (Ritchie, 2021). While extensively used in Asian countries, it is also imported to countries around the world for various human and industrial purposes. Soybean oil, in turn, is largely produced in North and South America and like PO, is also used in a wide range of food and industrial products (OEDC-FAO, 2021). Even though both PO and SO are extensively used for human and industrial use, these two lipids and their byproducts may also end up as a potential high-energy feedstuff in livestock diets. While the determination of the AME for refined SO has been widely reported (Pesti et al., 2002; Murugesan et al., 2017; Kerr et al., 2024), less data is available on the AME value of PO, with PO having a relative AME of approximately 75 % compared to SO (Huyghebaert et al., 1988; Wiseman and Salvador, 1991; Kerr et al., 2024). In general, saturated fats, such as PO, tend to be digested less compared to unsaturated fats/oils, such as SO, with widely used equations having been developed to predict AME for poultry in relation to a lipid's fatty acid (**FA**) and free fatty acid (**FFA**) concentrations (Huyghebaert et al., 1988; Ketels and De Groote, 1989; Wiseman et al., 1998).

Lipid digestion in poultry is inherently complex, especially in young poultry (Kroghahl, 1985; Jin et al., 1998; Ravindran and Abdollahi, 2021). Although lipid digestibility and the AME values of lipids have

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been studied for decades (March and Biely, 1957; Renner and Hill, 1961; Whitehead and Fisher, 1975), research has continued over time (Mossab et al., 2000; Kerr et al., 2016; Murugesan et al., 2017) with recent interest in increasing lipid digestion using emulsifiers or biosurfactants (Siyal et al., 2017; Wealleans et al., 2020a; Shoaib et al., 2023).

Biosurfactants or emulsifiers act by reducing the surface tension between two compounds to increase the active surface of lipids in order to improve micelle formation thereby improving lipid absorption. Emulsifiers have included compounds such as amino acids or proteins (Kalmar et al., 2014; Dabbou et al., 2019), bile (Polin et al., 1980; Atteh and Leeson, 1985), lecithin (Majdolhosseini et al., 2019; Nemati et al., 2021), lysophospholipids (Wealleans et al., 2020a; Ahmadi-Sefat et al., 2022), mono- or di-acylglycerides (Wang et al., 2020; Oketch et al., 2022), polyethylene glycol ricinoleate (Kaczmarek et al., 2015; Wisniewska et al., 2023), polysorbates (Wickramasuriya et al., 2020; Rao et al., 2023), and sodium stearoyl-2-lactylate (Upadhaya et al., 2018; Hoque et al., 2022). Because there is a discrepancy on the efficacy of emulsifiers and whether their potential effects are lipid-source dependent, the current experiments were conducted to determine potential interactive effects between lipid source (PO versus SO) and biosurfactant addition (none versus glycerol monolaurate-**GML**) on apparent total tract digestibility (**ATTD**) of gross energy (**GE**), including urinary energy losses, in growing broilers and on growth performance in young turkey poults.

Materials and methods

Animal care

All experimental procedures were approved by Iowa State University Institutional Animal Care and Use Committees, IACUC #23-052.

Energy digestibility

Straight-run Ross 308 broilers were obtained from a commercial hatchery (Welp Hatchery, Bancroft, IA) on day-of-hatch and raised in a 1.2 × 2.4 m floor pen with fresh litter and fed a commercial diet for 21 d. On d 21, 120 chicks were randomly selected and moved to 60 battery cages (33 × 51 cm; two birds/pen) where they had had *ad libitum* access to water and feed supplied in mash form. Birds were fed their respective Phase-1 dietary treatments for a 6-d acclimation period followed by a 4-d grab-sample excreta sampling period. On d 31, one bird was removed due to space limitations and fed their respective Phase-2 dietary treatment (reduced amino acid and mineral concentration coinciding with reduced nutrient needs, Table 1), being re-adapted to dietary treatments for another 6-d followed by a 4-d grab-sample excreta collection period. Body weights and feed consumption were measured on d 21, d 31, and d 41 to monitor general bird performance. The 5 treatments consisted of diets containing either 6 % added PO or SO in combination with either no emulsifier or 0.05 % glyceryl monolaurate, plus a control diet containing 6 % fine sand, resulting in 12 replications per dietary treatment.

Following collection within each phase, excreta samples, including urinary compounds, were dried at 75°C and subsequently ground through a 1-mm screen. Feed and excreta were analyzed for titanium based on the method of Leone (1973) where samples were ashed in an oven and then digested with sulfuric acid and hydrogen peroxide, followed by measuring absorbance using a UV spectrophotometer against a standard curve. The GE content of feeds and excreta, including urinary energy losses, was determined using an isoperibol bomb calorimetry (Model 6200, Parr Instruments, Moline, IL) and benzoic acid as a standard. Apparent total tract digestibility, including urinary energy losses, for each diet was accomplished using the indirect method with the ATTD (%) calculated as: $[1 - (Ti_{feed} \times GE_{excreta})/(Ti_{excreta} \times GE_{feed})] \times 100$. The energy digestibility of each lipid was calculated by subtracting the energy contribution of the basal diet from the test diet containing the added lipid and calculating the subsequent lipid-energy digestibility coefficient. These lipid-energy digestibility coefficients were multiplied to the respective GE of each lipid to determine AME for each lipid.

Table 1
Diet formulations for determination of apparent metabolizable energy in broilers.

	Phase-1[1]		Phase-2[2]	
Ingredient, %	Control	Lipid	Control	Lipid
Corn	60.05	60.05	61.44	61.44
Soybean meal	29.09	29.09	27.79	27.79
Dicalcium phosphate	2.16	2.16	2.10	2.10
Limestone	0.56	0.56	0.55	0.55
Sodium chloride	0.40	0.40	0.40	0.40
Vitamin mineral mix[3]	0.60	0.60	0.60	0.60
Choline chloride, 60 %	0.10	0.10	0.10	0.10
L-lysine·HCl	0.15	0.15	0.15	0.15
DL-methionine	0.26	0.26	0.25	0.25
L-threonine	0.09	0.09	0.08	0.08
Phytase[4]	0.04	0.04	0.04	0.04
Titanium dioxide	0.50	0.50	0.50	0.50
Sand[5]	6.00	-	6.00	-
Lipid[6]	-	6.00	-	6.00
GLM[7]	-	-		
Total	100.00	100.00	100.00	100.00

[1] Phase-1 treatment diets were fed from d 21-31 d of age and were formulated to contain 0.80 % calcium, 0.39 digestible phosphorus, and 1.02 % digestible Lys and met or exceeded TSAA, Thr, Trp, Ile, Val, and Arg:Lys ratios of 0.77, 0.67, 0.19, 0.68, 0.75, and 1.08, respectively. The control diet contained approximately 2,705 kcal AME_n/kg while the diets with added lipids contained approximately 3,225 kcal AME_n/kg.

[2] Phase-2 treatment diets were fed from d 31-41 d of age and were formulated to contain 0.78 % calcium, 0.38 digestible phosphorus, and 0.99 % digestible Lys and met or exceeded TSAA, Thr, Trp, Ile, Val, and Arg:Lys ratios of 0.78, 0.67, 0.19, 0.69, 0.77, and 1.10, respectively. The control diet contained approximately 2,720 kcal AME_n/kg while the diets with added lipids contained approximately 3,250 kcal AME_n/kg.

[3] Provided per kg of basal diet: vitamin A, 7,935 IU; vitamin D_3, 2,645 IU; vitamin E, 17.2 IU; menadione, 1.0 mg; vitamin B_{12}, 11 µg; biotin, 40 µg; choline, 429 mg; folic acid, 1.3 mg; niacin, 39 mg; pantothenic acid, 10 mg; pyridoxine, 1.0 mg; riboflavin, 5.3 mg; thiamine, 1.3 mg; Cu, 12 mg; Fe, 135 mg; I, 822 µg; Mn, 122 mg; Se, 0.24 mg; Zn, 121 mg.

[4] Ronozyme HiPhos 2700, DSM Nutritional Products Inc., Parsippany, NJ.

[5] Fine washed sand.

[6] Either palm oil or soybean oil depending on diet.

[7] Glyceryl monolaurate added at 0.05 % in place of corn depending upon diet.

Performance evaluation

For each of the two groups of poults, 1,800 day-of-hatch tom poults from a commercial hatchery (Nicholas Select, Group 1; Hybrid Converter, Group 2) were weighed and placed across 30 floor pens (2.4 × 2.4 m, 60 birds/pen) containing fresh wood shavings (Stanley Balloun Turkey Teaching and Research Farm, Iowa State University, Ames, IA). Upon placement, poults received electrolytes in the water (Balance, Aurora Pharmaceutical, Inc., Northfield, MN) for 3 d as part of standard poult rearing protocols. Birds were managed under commercial brooder conditions and fed a Phase-1 diet from d 1-14 and a Phase-2 diet that was fed from d 15-35, Table 2, with *ad libitum* access to water and mash fed at all times. Poults and feed were weighed at placement and d 35. Mortality was counted and weighed daily, and bird-days were used to adjust overall ADG, ADFI, and feed efficiency (gain:feed, **GF**). Dietary treatments consisted of diets containing either 5 % added PO or SO in combination with either no emulsifier, 0.05 % glyceryl monolaurate, or 0.10 % glyceryl monolaurate (Table 2), resulting in 10 replications per treatment across the 2 blocks of poults.

Statistical analysis

Each study was conducted as a completely randomized design with

Table 2
Diet formulations for the turkey performance study.

Ingredient, %	Phase-1[1]	Phase-2[2]
Corn	35.19	36.44
Soybean meal	46.35	45.63
Poultry meal	7.50	7.50
Dicalcium phosphate	3.23	-
Monocalcium phosphate	-	2.31
Limestone	0.85	1.30
Sodium chloride	0.35	0.35
Vitamin mineral mix[3]	0.30	0.30
Choline chloride, 60 %	0.30	0.30
L-lysine·HCl	0.36	0.32
DL-methionine	0.42	0.40
L-threonine	0.11	0.11
Phytase[4]	0.04	0.04
Lipid[5]	5.00	5.00
GLM[6]	-	-
Total	100.00	100.00

[1] Phase-1 treatment diets were fed from d 1-14 d of age and were formulated to contain 1.35 % calcium, 0.70 digestible phosphorus, and 1.75 % digestible Lys and met or exceeded TSAA, Thr, Trp, Ile, Val, and Arg:Lys ratios of 0.65, 0.58, 0.14, 0.60, 0.66, and 1.02, respectively, and approximately 2,950 kcal AME_n/kg.
[2] Phase-2 treatment diets were fed from d 15-35 d of age and were formulated to contain 1.24 % calcium, 0.62 digestible phosphorus, and 1.71 % digestible Lys and met or exceeded TSAA, Thr, Trp, Ile, Val, and Arg:Lys ratios of 0.65, 0.59, 0.15, 0.60, 0.67, and 1.03, respectively, and approximately 2,950 kcal AME_n/kg.
[3] Provided per kg of basal diet: vitamin A, 16,534 IU; vitamin D3, 5,556 IU; vitamin E, 33 IU; menadione, 5.6 mg; vitamin B12, 19 µg; biotin, 73 µg; folic acid, 0.7 mg; niacin, 102 mg; pantothenic acid, 18 mg; pyridoxine, 4.0 mg; riboflavin, 11.2 mg; thiamine, 1.3 mg; Cu, 14 mg; Fe, 138 mg; I, 1,500 µg; Mn, 105 mg; Se, 0.30 mg; Zn, 105 mg.
[4] Ronozyme HiPhos 2700, DSM Nutritional Products Inc., Parsippany, NJ.
[5] Either palm oil or soybean oil depending on diet.
[6] Glyceryl monolaurate added at either 0.05 or 0.10 % in place of corn depending upon diet.

treatments analyzed in a factorial arrangement and collection period retained as a blocking factor in the battery study and group retained as a blocking factor in the performance study. The pen was considered the experimental unit in both experiments. Statistical analysis was facilitated using PROC GLM (SAS Inst. Inc., Cary, NC) with significance set at $P < 0.10$.

Results

Lipid Composition: Composition and quality of indices of the PO and SO are reported in Table 3. Palm oil contained a greater amount of saturated FA compared to SO and neither oil contained appreciable amounts of FFA or moisture, insoluble, or unsaponifiables, and were considered high quality as indicated by their low peroxide and anisidine values.

Energy Digestibility: Apparent metabolizable energy values for PO or SO in combination with 0 or 0.05 % GML are reported in Table 4. There was an interaction between lipid source and emulsifier addition where the addition of GML had no impact on the ATTD of GE of SO but improved the ATTD of PO from 77.11 % to 88.21 % ($P = 0.03$). This increase amounted to an additional 1,045 kcal AME /kg PO (7,259 versus 8,304 kcal AME/kg, respectively). In comparing the oils without any GML addition, PO had a lower ATTD of GE (77.11 %) compared to SO (96.48 %) resulting in its calculated AME being only 80 % of that for SO (7,259 versus 9,092 kcal/kg, respectively).

Although performance parameters for broilers kept for short periods in batteries are not reflective of longer term-pen studies, there was no interaction observed between lipid source and emulsifier addition, and no lipid source or emulsifier addition effect ($P > 0.10$) for ADG or ADFI. There was also no interaction observed between lipid source and emulsifier addition and no emulsifier effect ($P > 0.10$) on feed efficiency. However, broilers fed diets containing PO resulted in a lower

Table 3
Composition and quality indices of lipid samples.

Ingredient, %	Palm oil	Soybean oil
GE[1], kcal/kg[2]	9,414	9,427
FA, % of total fat[3]		
Caprylic (8:0)	0.05	< 0.02
Capric (10:0)	0.04	< 0.02
Lauric (12:0)	0.42	< 0.02
Myristic (14:0)	1.09	0.07
Palmitic (16:0)	41.27	9.96
Palmitoleic (16:1)	0.24	0.14
Margaric (17:0)	0.09	0.09
Stearic (18:0)	4.06	3.77
Oleic (18:1)	37.18	20.77
Linoleic (18:2)	8.95	52.25
Linolenic (18:3)	0.13	6.87
Arachidic (20:0)	0.35	0.28
Gadoleic (20:1)	0.19	0.26
Behenoic (22:0)	0.07	0.30
Other Fatty Acids	0.18	0.24
UFA:SFA	0.97	5.49
FFA, %[3]	0.16	0.02
Moisture, %[3]	< 0.10	< 0.10
Insolubles, %[3]	0.06	0.03
Unsaponifiables, %[3]	0.35	0.51
PV, Meq/kg[3]	14	11
AnV[3,4]	3	2

[1] Abbreviations: UFA:SFA, unsaturated FA to saturated FA ratio; FA, fatty acid; FFA, free fatty acids; PV, peroxide value; AnV, anisidine value.
[2] Analyzed by by USDA-ARS, Ames, IA.
[3] Analyzed by Eurofins, Des Moinse, IA.
[4] There are no units for anisidine value.

Table 4
Interactive effects between lipid source and emulsifier addition on the apparent total tract digestibility of lipids in broilers.

	GE, %	ATTD, %	AME, kcal/kg	ADFI, g	ADG, g	G:F
Palm oil						
None	9,414	77.11[c]	7,259	141.7	88.8	0.627
GML	9,414	88.21[b]	8,304	137.8	85.5	0.620
Soybean oil						
None	9,424	96.48[a]	9,092	140.4	89.0	0.633
GML	9,424	96.02[a]	9,049	140.9	89.5	0.635
SEM	NA	2.69	NA	3.67	2.63	0.0063
P values						
Lipid × Emulsifier	NA	0.03	NA	0.55	0.47	0.51
Lipid	NA	0.01	NA	0.79	0.43	0.10
Emulsifier	NA	0.05	NA	0.65	0.60	0.71
Lipid						
Palm oil	9,414	82.66	7,782	139.7	87.2	0.623
Soybean oil	9,424	96.25	9,071	140.7	89.2	0.634
Emulsifier						
None	9,419	86.80	8,176	141.1	88.9	0.630
GML	9,419	92.12	8,677	139.3	87.5	0.628

Abbreviations: GE, gross energy; ATTD, apparent total tract digestibility; ADFI, average daily feed intake; ADG, average daily gain, AME, apparent metabolizable energy; G:F, gain to feed ratio; GML, glyceryl monolaurate; SEM, standard error of the mean; P value, probability of model parameter.
Energy data consists of 24 observations per dietary treatment consisting of 12 observations per period in each of 2 collection periods. Performance data consists of 12 observations per dietary treatment. Each group of broilers were fed a common diet from d 1 to 21, a period-1 diet from d 21 (922 g average BW) to d 31 (1,814 g average BW) with fecal collection on d 28-31; 2 birds/pen; followed by a period-2 diet from d 31 to d 41 (3,019 g average BW) with collection on d 38-41; 1 bird/pen. Period was a blocking factor in the statistical analysis for energy data. Diets contained 6 % added lipid with ATTD of GE determined for each lipid by using the indirect method with titanium dioxide as the indigestible marker. The ATTD of each lipid was calculated by subtracting the energy contribution of the basal diet from the test diet containing the added lipid and calculating the subsequent lipid-energy digestibility coefficient.

feed efficiency ($P = 0.10$) compared to broilers fed diets containing SO.

Poult Performance: Performance criteria of poults fed diets containing 5 % PO or SO in combination with 0, 0.05, or 0.10 % GML are reported in Table 5. There was an interaction between lipid source and emulsifier addition on ADFI ($P = 0.01$) where it was observed that the addition of 0.10 % GML reduced ADFI in poults fed diets containing PO compared to poults fed 0 or 0.05 % GML, while the addition of either 0.05 or 0.10 % GML reduced ADFI in poults fed diets containing SO compared to poults fed no GML. The reduction in ADFI due to diet was reflected in a similar interaction between lipid source and emulsifier addition on ADG ($P = 0.01$) where the addition of either 0.05 or 0.10 % GML reduced ADG in poults fed diets containing SO compared to poults fed no GML, while the addition of GML was largely without effect in poults fed diets containing PO. There was no interaction between lipid source and emulsifier addition on feed efficiency ($P > 0.10$). However, there was a diet effect as poults fed diets containing PO had a poorer feed efficiency compared to poults fed diets containing SO ($P = 0.01$). The main effect of emulsifier was inconsistent in that poults fed the diets containing 0.10 % GML had the greatest feed efficiency compared to poults fed the diets containing 0.05 % GML, with poults fed diets containing no emulsifier being intermediate ($P = 0.10$).

Discussion

The compositional profile of PO and SO were similar to expectations with only minor differences relative to past research from this laboratory (Lindblom et al., 2017, 2019; Kerr et al., 2018, 2024). The lack of compositional variation from literature values was expected because both the PO and SO used in the current experiments were food-grade quality (i.e., refined, bleached, and deodorized) which is also the reason both lipids were low in FFA, dilutants (i.e., moisture, insoluble, and unsaponifiable material), and peroxidation products (peroxide and anisidine values).

Determination of the caloric value of feedstuffs, especially lipids, is a difficult task which has been summarized in detail by others (Dale and Fuller, 1982; Mateos et al., 2019; von Schaumburg et al., 2019; Wu et al., 2020; Kerr et al., 2024). Most research determining caloric values of feedstuffs often includes glucose in the basal diet and then determining the energy value of the test ingredient by substituting glucose with the test ingredient, using a published AME value of glucose (Anderson et al., 1958). Because of the inherent difficulties of showing small differences in energy levels of digestibility among diets or feedstuffs, finely powdered sand has been used as a non-caloric filler (Andrews et al., 1972; Boomgaardt and Baker, 1973; Baker, 1977; Rowland and Hooge, 1980). The use of fine sand in the current study maximized the energy differences between the basal diet which contained 6 % sand compared to test diets which contained 6 % added lipid.

In the current study the AME determined for SO with no added emulsifier of 9,092 kcal/kg is within the range of that reported by others (Pesti et al., 2002; Murugesan et al., 2017; von Schaumburg et al., 2019; Elmore et al., 2023; Kerr et al., 2024). In contrast, less data is available on the AME value of PO, with PO having a relative AME of approximately 75 % compared to SO (69 %, Huyghebaert et al., 1988; 78 %, Wiseman and Salvador, 1991; 58 %, Pesti et al., 2002; 83 %, von Schaumburg et al., 2019; 88 %, Kerr et al., 2024). The 85 % relative AME value for PO compared to SO (7,259 vs 9,092 kcal/kg, respectively) observed in the current study falls within this range.

Nutritional strategies to improve lipid digestion is important given that lipid digestion is limited in young poultry, especially the first two weeks post-hatch (Kroghahl, 1985; Jin et al., 1998; Mossab et al., 2000; Lilburn and Loeffler, 2015; Ravindran and Abdollahi, 2021). Saturated fats have a lower digestibility compared to unsaturated fats/oils (Huyghebaert et al., 1988; Ketels and De Groote, 1989), more so in young poultry compared to adult poultry (Wiseman et al., 1998). This is likely due to a limited lipase activity and bile salt production (Kroghahl and Sell, 1989; Noy and Sklan, 1995; Ravindran et al., 2016).

Given the energy digestibility discrepancy between PO and SO in the current experiment and by others (Huyghebaert et al., 1988; Wiseman and Salvador, 1991; Pesti et al., 2002; von Schaumburg et al., 2019; Kerr et al., 2024), it might be expected that dietary emulsifiers would improve the digestibility of more saturated lipids to a greater extent than more unsaturated lipids. In the energy digestibility study, PO exhibited a 14 % improvement in ATTD of GE when GML was supplemented to the diet compared to no improvement in ATTD of GE for SO. A lipid source by emulsifier interaction on energy digestibility is supported by Atteh and Leeson (1985, C16:0 vs C16:0/18:1), Jansen et al. (2015, SO vs lard), Allahyari-Bake and Jahanian (2017, SO or SO-FFA vs PO), and Tavares et al. (2022, poultry fat vs tallow), but not by others (Zhang et al., 2011, SO vs tallow vs poultry fat; Zosangpuii et al., 2011, SO vs PO; Zaefarian et al., 2015, SO vs tallow; Polycarpo et al., 2016, SO vs tallow; Majdolhosseini et al., 2019, SO vs poultry fat; Solbi et al., 2021, SO vs flaxseed oil vs sesame seed oil). The lack of an interactive effect between lipid source and emulsifier addition is also supported by Wealleans et al. (2020b) who reviewed trials assessing the efficacy of lysolecithin-derived biosurfactants and concluded that the response to lysolecithin supplementation was not affected by the FA profile (e.g., PO, poultry fat, tallow, and vegetable oil) of lipids added to the diet. The inconsistency of these results is perplexing and warrants further investigation.

The dramatic increase in ATTD of GE when GML was added to a diet containing PO (an increase in the calculated AME of PO by 1,045 kcal/kg) obtained in the broiler battery study led to the hypothesis that performance would be subsequently improved. This was, however, not the case. In the turkey poult study, the interactive effect between lipid source (PO versus SO) and emulsifier addition was relative to reductions in feed intake and subsequently on poult growth, but not on feed efficiency. In light of this unexpected response, performance data for the battery study was evaluated. It did not, however, reveal a reduction in broiler feed intake or growth due to emulsifier addition. In addition, the broiler results were similar to the poult study in that there was no interaction between lipid source and emulsifier addition on feed

Table 5
Interactive effects between lipid source and emulsifier addition on the turkey poult performance.

	ADFI, g	ADG, g	G:F
Palm oil			
None	53.2[b]	35.7[bc]	0.670
GML, 0.05 %	53.8[b]	35.6[bc]	0.661
GML, 0.10 %	50.4[c]	34.1[c]	0.675
Soybean oil			
None	57.5[a]	39.5[a]	0.687
GML, 0.05 %	52.9[bc]	35.9[b]	0.679
GML, 0.10 %	53.5[b]	37.0[b]	0.693
SEM	0.80	0.58	0.0064
P values			
Lipid × Emulsifier	0.01	0.01	0.99
Lipid	0.01	0.01	0.01
Emulsifier	0.01	0.01	0.10
Lipid			
Palm oil	52.5	35.1	0.669
Soybean oil	54.6	37.5	0.686
Emulsifier			
None	55.3[a]	37.6[a]	0.679[ab]
GML, 0.05 %	53.4[b]	35.7[b]	0.670[b]
GML, 0.10 %	52.0[b]	35.6[b]	0.684[a]

Abbreviations: ADFI, average daily feed intake; ADG, average daily gain; G:F, gain to feed ratio; GML, glyceryl monolaurate; SEM, standard error of the mean; P value, probability of model parameter.
Data consists of 10 observations per dietary treatment consisting of 5 observations per treatment in each of 2 groups of poults. Poults were fed a Phase-1 diet from d 1 to 14 and a Phase-2 diet from d 21 to 35 d of age. Average initial and final BW were 60 and 1,356 g, respectively. Diets contained 6 % added lipid and were fed in meal form over the 35-d trial. Group was a blocking factor in the statistical.

efficiency. This lack of an interaction between lipid source and emulsifier addition was surprising given the differences in the AME determined for the complete diet in the broiler battery study (PO-none, 3,142; PO-GLM, 3,225; SO-none, 3,265; SO-GLM, 3,262 kcal AME/kg diet; data not shown). It is worth noting, however, that in both the broiler battery study and in the poult pen study that birds fed diets containing PO had a poorer feed efficiency compared to birds fed diets containing SO, which would be reflective of the different AME values determined for PO and SO, respectively.

In conclusion, the addition of GML improved the ATTD of GE for PO but had no effect on the ATTD of GE for SO. This improvement in energy digestibility, did not however, translate to an improvement in performance indicators in broilers kept in batteries for 20 d or in poults kept in floor-pens for 35 d. Differences in feed efficiency were observed in both broilers and turkey poults where birds fed diets containing SO had a greater feed efficiency compared to birds fed diets containing PO.

APPENDIX

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the USDA or Iowa State University and does not imply approval to the exclusion of other products that may be suitable. The USDA is an equal opportunity provider and employer.

DISCLOSURES

The authors declare that Berg+Schmidt America, LLC (Libertyville, IL 60048) donated the glyceryl monolaurate used in this project and the authors have no commercial or financial relationships that could be construed as a potential conflict of interest.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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